A COMPARATIVE STUDY OF SUPPLEMENTARY PROGRAMED AND CONVENTIONAL METHODS OF INSTRUCTION IN TEACHING FRESHMAN CHEMISTRY 1015 AT OKLAHOMA STATE UNIVERSITY

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CHAPTER I

INTRODUCTION

There are several factors that contribute to the enrollment explosion in the nation's colleges and universities. The post World War II "baby boom," more high school graduates aspiring for a college education, realization that a high school diploma is no longer a guarantee of a good job, and the high percentage of the teenage population seeking a college education in order to qualify for employment in various fields of endeavor are but a few of these factors.

Sidney Tickton (1) has written that the shape of American higher education between now and 1980 will be determined in considerable measure by the sheer size of the enterprise and he lists eleven demographic and financial factors that lend credence to his projections:

> 1. the crystallization of a national consensus that every high school graduate who can profit from it should have at least two years of further education;
>
> 2. a very significant increase in the proportion of students enrolled in public junior or community colleges or other types of two-year public post-high-school educational institutions;
>
> 3. a sharp rise in the number of students enrolled in higher education--sharper than the estimates published by most government agencies concerned with the problem;
>
> 4. a considerable increase in the number of adults enrolled in higher education institutions;

5. a continuation of the historic shift of the center of gravity from the private to the public institutions, as the latter attract an ever-growing proportion of students;

6. the conversion of a number of private institutions to state-controlled or state-related status;

7. the development of strong statewide coordinating boards or statewide systems of higher education in nearly every state, with influence extending over all areas of education beyond the high school, both public and private;

8. a continued upsurge in graduate education such that, during the fifteen years ending in 1980-81, the total number of doctorates earned will be no fewer than 375,000—one and one-half times the total number of doctorates earned in the entire earlier history of the nation;

9. a substantial increase in the number of faculty members and assistants—but not substantial enough to match the increase in enrollments (the gap will be filled by larger classes, use of technological aids to instruction, and reliance on more assistants in teaching);

10. greatly increased spending by institutions of higher learning to meet expanding needs for their services;

11. an expanding gross national product adequate to finance the needed expansion in higher education if the American people choose to allocate their public funds to that ends.

In addition to the above factors, social and economic pressures, increased student loans, more scholarships, Work-Study Programs, and higher family income all encourage young people to seek a higher education. The increased enrollment raises a major problem that confronts university and college administrators and faculty members (2). Federal legislation that has influenced higher education includes the National Defense Education Act of 1958, which was later amended to include fields in the arts and sciences; the Higher Education Facilities Act of 1963, to help colleges increase physical facilities; the Manpower Development Training Act of 1963, which established programs that utilize college facilities and instructors; and the Higher

Education Act of 1965, which extended and increased the availability of higher education. Colleges and universities also have yet to fully experience the enrollment created by the 1966 "Cold War" G.I. Bill of Rights.

Further, higher education is becoming more available as institutions of learning are being built in closer proximity to the students' homes. These institutions are usually in the form of new junior colleges, new community colleges and extension centers affiliated with larger universities and colleges.

Other factors that are contributing to the burgeoning demand for college education include increased need for adult education due to lengthened life span, increased enrollment of women in higher education, and increased enrollment of students from minority groups whose place in the mainstream of higher education is not representative of their ratio to the general population.

The yearly rise in enrollment in colleges and universities shows unprecedented gains. Oklahoma's colleges and universities enrolled 106,130 students in the fall of 1968, a gain of 6.0 per cent over the previous year's enrollment which was lower than the national level of 8.7 per cent (3). Estimates indicate that the crowded classroom problem is just beginning. Projections of the U.S. Office of Education (4) are that the number of college students will rise from 5.0 million in 1964 to 8.7 million in 1974, an increase in excess of 57 per cent over a 10 year period. Tickton (1) has tabulated information to show a total enrollment for higher education in the fall of 1965 at 5,920,000 and projects an enrollment of 12,000,000 by 1980, an increase of 103 per cent. He rationalizes that his enrollment projections are larger than those published by a number of Federal government agencies because they allow for a substantially greater part-time enrollment in higher education programs by people holding full-time jobs in business, industry, and government.

The problem engendered by the vast increase in enrollments in colleges and universities magnifies another problem of equal importance which is that of supplying enough qualified teachers to teach the many students matriculating in the schools.

The U.S. Office of Education estimates that the nation's colleges' and universities' instructional staff will rise from the 1965 approximate figure of 320,000 to approximately 433,000 by 1971 (5). To this increase of 113,000 must be added a figure due to the attrition of present faculty, estimated by various agencies as ranging from 1.8 per cent to 6 per cent annually, bringing the total needed new faculty to about 160,000. Of 95,000 to 120,000 new doctorates which will be produced in the next 6 years, about 80,000 or from 60 to 85 per cent must go into college teaching if one half of the faculty added between 1965 and 1970 are to have the doctoral degree.

Tickton (1) lists 400,000 as the actual figure for full-time faculty, part-time faculty, assistant instructors, teaching fellows, and teaching assistants in 1965-1966 and an estimated 745,000 for 1980-1981, an increase of 345,000 representing an 86 per cent increase in faculty. The student enrollment increase will be 103 per cent by this time. Realizing this differential increase, he predicts that leading institutions will meet this discrepancy between faculty-student percentage increases by making use of technological aids and a greater number of faculty assistants as practical methods of providing high quality education while meeting a portion of the student growth problem. Should one embrace either projection, increases in enrollment in higher education are anticipated with an expected shortage of qualified faculty for at least the next 10 years.

Meeting the challenge of educating large numbers of students with a limited faculty has encouraged methods that depart from the traditional face-to-face classroom method.

A natural outgrowth of the pressures of teaching more students with fewer faculty is the search for new instructional media. Although it is a fact that television, audio-visual materials and films may provide enrichment and stimulate interest, they are weak in student participation and reinforcement (6) (7) (8) (9).

An instructional method which is devised to offset the above weakness is that of programed instruction. In fact, a review of the literature, given in Chapter II, will support the writer's view that a considerable amount of research on programed instruction has been conducted during the last five years. Indeed, no teaching medium has ever come into use in such an atmosphere of research, born, as it was, in a learning laboratory, nurtured on theory and for some years knowing no friends except scholars (5). This research leaves little doubt that programs do teach. A great deal of learning seems to take place, regardless of the kind of program or the kind of students. Frequently programs can teach as well as a human teacher and sometimes even better (10). Programs have been used successfully at all levels of the educational system, at all levels of ability from slow learners to the very best students, and to teach a great variety of academic subject matter and verbal and manual skills (11) (12) (13) (14).

Teachers have produced knowledge for thousands of years without being able to specify the conditions and principles according to which learning develops, and most students have learned from unprogramed presentations during that time. What, then, is the promise of programed instruction? Simply that the complexities of modern education and industrial training require the application of all our understanding of instructional techniques so that the limited number of available teachers and instructors will be able to provide the most efficient instruction possible for ever-increasing numbers of students. The current development of auto-instructional methods based on specific learning principles is a first and necessary step in the accomplishment of this objective (8).

Programed instruction, if it lives up to its expectations, can do much to overcome the difficulties that accompany mass education and limited staff.

Williams (15) has written that programed instructional methods are being used extensively at the university level, although probably less widely in science and engineering than in some other subjects.

There is some evidence of growing disenchantment among educators concerning programed instruction and this has resulted in some new efforts to revise the techniques of programing. Pressey and Kinzer (16) attempted to use programs as supplements to course offerings. These researchers defined this work as adjunct auto-instruction and stated that "adjunct auto-instructional procedures are designed to clarify and extend meanings, to correct misunderstandings, to confirm the students' choice, to point out errors, and to guide him to the correct answer."

Jay A. Young (17) echoed the same theme in a symposium on programed instruction in chemistry. He remarked that when programs are used as adjuncts or supplements to a good text in elementary chemistry the students tend to be weaned away from the programed instructions rather quickly. They learn from the examples set by the programs how to extract information from a text for themselves.

Through the present study the investigator will seek to determine the effect on achievement scores by comparing the use of supplementary programed materials with the conventional method of teaching a general chemistry course at Oklahoma State University. The auto-instructional procedure was used in this investigation, i.e., students read the supplements on their own outside of the regularly scheduled class session.

Statement of the Problem and Hypotheses

The purpose of this study is to ascertain the effectiveness of using supplementary programed instruction as a method of teaching Chemistry 1015 at Oklahoma State University. The study is designed to answer the central question: Can programed instruction serve as an effective adjunct to the textbook to teach Chemistry 1015 with no significant loss of achievement in the course? As an attempt to determine a solution to the problem the hypotheses that follow were formulated:

I. A null hypothesis to be tested is that there is no significant difference in achievement scores due to the use of supplementary programed materials compared with the conventional method of instruction among freshman and sophomore students of Oklahoma State University enrolled in Chemistry 1015 relative to:

A. ACT scores and cumulative test scores

B. ACT scores and MAT scores

C. Matched groups and cumulative test scores

II. There is no significant difference among students enrolled in Chemistry 1015, relative to:

A. The number of students who knew and those who did not know about the availability of programed materials to supplement the textbook used in Chemistry 1015.

B. The number of students who used programed instruction frequently, occasionally, very little, very, very little, or none at all.

C. The number of students who became aware of the existence of programed instructional materials through the instructor's advice, fellow students, library, or book store.

D. The number of students whose study time for Chemistry 1015 was shortened, lengthened, or was not affected by use of the programed materials.

III. There is no significant difference in the number of students that enrolled in Chemistry 1015 who favored programed materials, or teacher conferences, or the textbook as the most valuable learning aid for the course.

IV. There is no significant difference in the number of students enrolled in Chemistry 1015 who indicated that they liked, did not like, or had no feeling relative to the use of programed materials for the course.

Definitions of Concepts

1. Conventional instruction is instruction utilizing lecture, class discussion and textbook readings during a regularly scheduled class period.

2. Non-directed programed instruction refers to study utilizing programed materials outside of class time.

3. Directed programed instruction is study utilizing programed instruction materials during a regularly scheduled class period with the instructor over-seeing the group and answering any individual questions.

4. Feedback refers to knowledge of results as to whether the answer or choice is correct or incorrect. In case of error, information may be given as to why the response was not right.

5. Cue is a stratagem used to focus the attention of the student and lead him to the required answers. Capitals, underlining, color, and special grammatical constructions are all used to "cue" an answer.

6. Frame is a unit of the program that requires a response of the student.

7. Linear program is a program especially devised to advance the student step by step to his learning goal and so organized that he will make minimal errors.

8. Branching program is a sequence of learning steps organized to provide logical progress and correction for incorrect answers; the frames are usually in the form of multiple-choice type questions. At the end of the program there is a short objective test, so the student can find whether he mastered the material in the program or not. If there is an error or uncertainty, the correct answers given on the next page also direct him to the page in the program where the point is discussed for whatever review or classification is necessary.

9. Operant conditioning is a psychological term used to indicate the conditioning which results when a subject is required to volunteer the correct response in order to gain reinforcement.

10. Reinforcement is the process of confirming the progress of a student by making him aware of his correct behavior as he proceeds. It derives from the psychological view that rewarding an organism makes repetition of the rewarded behavior more likely.

11. Step size refers to the amount of information in a program frame. A very small advance on previous frames is called a small step size. When the program moves forward by large steps, it is presenting materials in frames which carry much fresh material on each occasion.

12. Stimulus is any information, request, question, order, etc., which calls upon the student to make a response.

13. Achievement is a measure of the students' mastery of the material of the course.

14. Automated instructions are instructional methods utilizing any material, means, or devices to replace or supplement standard instruction by means of a wholly or partially automated presentation prepared in advance.

15. Chemistry 1015 is the first semester of a two-semester course in freshman chemistry for non-majors in chemistry at Oklahoma State University.

16. Minimum attainment tests (MAT) are tests administered to students enrolled in Chemistry 1015 to determine their minimal progress at certain intervals during the semester.

Assumptions

1. That there is random distribution in the four sections due to enrollment procedures at Oklahoma State University.

2. The matching of groups based on ACT scores will be sufficiently accurate as a measure of the students' previous training in order to allow a statistical comparison between matched groups.

3. The measuring instruments, since they are identical for both groups, will not offer a variable of enough significance to invalidate the study.

4. That the Hawthorne effect can be somewhat controlled by limiting the awareness of students of the experimental study.

5. That the effectiveness of instruction can be determined by teacher made test scores.

Limitations of the Study

1. The study will be restricted to freshman and sophomore students enrolled in Chemistry 1015 at Oklahoma State University during the Fall Semester, 1968.

2. This study is not concerned with the reasons for the occurrence or non-occurrence of significant differences in either direction.

3. Although a large number of studies will be cited in the review of the literature in which time was a factor of consideration, this study does not consider the time factor in relation to achievement.

Significance of the Study

With all the new teaching methods that have been developed in recent years, there needs to be more empirical evidence of the effects of these methods before we accept them as being better than or equal to the conventional methods of teaching. This study should reveal the effect of using programed materials as adjuncts to a good text in elementary chemistry on student achievement in freshman chemistry at Oklahoma State University.

Summary

This chapter has been concerned with the massive enrollment problem as it affects and will continue to affect institutions of higher education for at least the next ten years. The complexities of modern education and industrial training require the application of all our understanding of instructional techniques so that the limited number of teachers will be able to effectively teach the ever-increasing number of students. Programed materials, used as adjuncts or supplements to adopted textbooks, can do much to overcome the difficulties that are concomitant with mass education and shortage of teachers. This writer endeavored to establish the rationale, the limitations, the assumptions, and the hypotheses that would lend support for the necessity of a study of its nature.

CHAPTER II

REVIEW OF LITERATURE

Educational Technology

Education has been one of the prime stimuli for development of sophisticated technology in our society, but ironically it has made less use of technology than industry and the armed forces. In fact, education has proved to be one source of strong resistance to the use of technology for its own purposes. However, stimulated by the growing shortage of faculty members, the increase in students, and problems of cost, and with encouragement from some of the major foundations, the situation is shifting rapidly today (18).

Paul Mort (19) has stated, in describing what is commonly called the "Mort Gap," that early studies indicated that change in the American schools comes through a most glaringly slow process and follows a predictable pattern. Furthermore, between insight into a need and the introduction of a way of meeting the need that is destined for general acceptance, there is typically a lapse of a half century.

Skinner (20) makes the point that education is perhaps the most significant branch of scientific technology. Education affects the life of us all. Concerned educators can no longer allow the exigencies of a practical situation to suppress the tremendous improvements which are in reach. The practical situation must be changed.

Programed instruction is the kind of learning experience in which a "program" takes the place of a tutor for the student, and leads him through a set of specified behaviors designed and sequenced to make it more probable that he will behave in a given desired way in the future - in other words, that he will learn what the program is designed to teach him. Sometimes the program is housed in a "teaching machine" or in a "programed text." If so, the machine or book is little more than a case to hold the program. The program is the important thing about programed instruction (21).

Most teachers agree that if learning is to occur, a rather rigid, though friendly, control of the student is necessary. A major problem has been to exercise this control. By what might be called a psychological subterfuge, programed instruction can control the student at least to a remarkable degree. However, control by itself is insufficient. The knowledge to be imparted must be presented in an order which is understandable to the student. (This really is the point). This knowledge is usually presented in a linear or an intrinsic or branching program (22).

A linear program consists of a series of expository statements, in which the student is interrogated as he fills in the blanks. The student is lead in a direct linear manner from the initial to the concluding statement. A branching or intrinsic program consists of a series of pairs of exposition-question sets. Each of the several direct questions which is used in such a program is intrinsic with the exposition which precedes the question (17).

Both types have their particular areas of use and their vigorous proponents. Both linear and intrinsic techniques can be used. Many of the best recently produced programs include both features, although one or the other will predominate.

If a student cannot think of a word or words to fill in the blank, he may look at the answer in the margin and then proceed. Because students are not, in a properly prepared program, challenged beyond their ability - although they may indeed be challenged beyond their ability - they do not tend to look at the answer in the margin without first attempting to determine their own answers. Students quickly recognize that they are only cheating themselves when they look at the answer without first attempting their own answers. Since no grade is given for a good or a poor answer, there is little temptation to use the program incorrectly (10).

When the student cannot supply the correct answer, the author of the program has failed. A program is, quite literally, a test in which the student supplies the answers. But if the student gives an answer that differs from the author of the program, it is the programer who is wrong, not the student. The student is no longer under the control of the program writer, and in such an event the program must be revised to be "error free" as possible (usually a 5 to 10 per cent error rate is regarded as acceptable) (10).

Psychological Theory

Seven basic factors that have been deduced from psychological principles are involved in programed instruction as follows (23) (24) (25):

1. An active response is required from the learner;
2. Stimulus material is presented in short steps (frames) which insure correct responses;
3. Positive reinforcement is provided for correct responses (presumably by seeing that one's answer is correct);
4. The program moves from highly prompted frames which insure correct responses to unprompted terminal frames (criterion frames). The criterion frames and criterion behavior called for in these frames together define the objective to be attained by the programed learning sequence;
5. The movement from highly prompted initial frames to unprompted criterion frames follows a procedure of reinforcing successive approximations to the "desired response," this procedure being largely characterized by calling for the criterion behavior in frames with successively fewer and fewer prompts;
6. Sufficient redundancy is built into the sequence to assure retention;
7. Sufficient variation is built into the nature of the frames (stimulus conditions for the desired response) and the responses called for so that responses learned have the desired generalizability.

The Reinforcement Theory and Programed Instruction

Early researchers explored and included concepts of what Skinner later called "reinforcement." The expression "law of effect" was used much earlier by Thorndike to mean the same thing as the principle of reinforcement. Skinner was the first to take the position that certain behavior was the result of certain identifiable stimuli, and that other behavior does not originate from any identifiable source of stimulation; this kind of behavior he called "emitted" or "operant" behavior. This concept was to make a great impact on educational theories in general and the psychology of learning in particular (26).

In a paper presented before his colleagues in 1954 Skinner remarked (26):

> Some promising advances have recently been made in the field of learning. Special techniques have been designed to arrange what are called 'contingencies of reinforcement' the relations which prevail between behavior on the one hand and the consequences of that behavior on the other--with the result that a much more effective control of behavior has been achieved. It has long been agreed that an organism learns mainly by producing changes in its environment, but it is only recently that these changes have been carefully manipulated.

The concern of researchers with being able to manipulate the organism's environment in order to effectively control its behavior grew out of the awareness that in the traditional use of T-mazes and other psychological problem boxes the effects produced by the organism's behavior are left to too many fluctuating circumstances. There is many a slip between the turn-to-the-right and the food-cup at the end of the alley. Techniques of this sort provide only rough data from which meaningful results can be extracted only by averaging many cases.

Skinner has described two principal techniques for creating control of behavior in the field of learning. He emphasized that the law of effect was in full force in these efforts to make sure that effects do occur and that they occur under conditions which are optimal for producing learning. He boasted, in the first instance, that once he had arranged the particular type of consequence called a "reinforcement" his techniques permitted him to shape the behavior of an organism almost at will. This he would do in his classes in elementary psychology at Harvard University by conditioning a pigeon. Simply by presenting food to a hungry pigeon at the right time - he could shape up three or four well-defined responses (stamping the foot, pacing the floor in pattern of figure eight, etc.) during a single class period (9).

The second important advance in technique permitted him to maintain behavior in given states of strength for long periods of time, i.e., reinforcements continue to be important long after an organism has acquired a certain behavior. They are necessary to maintain the behavior in strength (9).

Skinner's concept of reinforcement is very influential in the area of programed instruction because it is in good scientific order, its accomplishments in the laboratory have been impressive, and it is generally thought to be a sound approach to the analysis of learning and teaching (27). At the heart of any learning lies the practice of what Skinner calls "reinforcement" (28).

Although a whole range of learning theory positions have been reflected in programed instruction, there is little question about the movement having been dominated by the Skinnerian operant conditioning theory of learning, as previously stated. It is still too early to assess the final effects of this theoretical development on the full involvement of programed instruction, but it is apparent that during the last six years a countermovement has been formed. It is not surprising to find that the traditionally antagonistic theoretical positions of stimulus-response associationists and gestalt-field psychologists have become a rallying point in programed instruction.

Almost seven years ago Pressey made the observation that there is disturbing evidence that current auto-instruction is not up to the claims made for it, that the current "boom" might be followed by a "bust." Further he declared (29):

> The archvillain leading so many people astray is declared to be learning theory! No less charge is made than that the whole trend of American research and theory as regards learning has been based on a false premise—that the important features of human learning are to be found in animals. Instead the all-important fact is that human has transcended animal learning. Language, number, such skills as silent reading, make possible facilitations of learning, and kinds of learning impossible even for apes. Auto-instruction should enhance such potentials. Instead, current animal-derived procedures in auto-instruction destroy meaningful structure to present fragments serially in programs, and replace processes of cognitive clarification with largely rote reinforcings by bit learnings.

There have been provocative critiques of Skinner's concept of teaching machines and programed instruction. Thelen (30) expresses the following doubts and criticisms:

> First, the notion that the learner must be rewarded at each step is by no means proved. Experiments similar to Skinner's studies on rats have shown that latent learning unguided and unrewarded does take place.
>
> Second, if we assume that reward is necessary at each step, the question becomes one of deciding how to give the reward. The present answer is to have steps so easy that the student makes very few errors.... The doubt is that continuous success is in fact rewarding... Reports that boredom sets in after the first few hours of programed instruction seem to be practical evidence.

The objections to the Skinnerian assumption underlying programed instruction are reflected in many of the controversial issues which have arisen in recent years on learning theory; however, these issues are not only pertinent to programing approaches but are likely to be basic in any theory of instructional technology. An S-R-theory-centered-programer considers learning a change of behavior which occurs as the result of practice or doing. To a gestalt-field-programer, learning is a cognitive process of developing new insights or modifying old ones. In preparing programed materials, the gestalt-field-programer is concerned with helping the learner to pursue his purposes, see new ways of utilizing elements of his environment, and get a sense of or feeling for pattern or relationships. Learning according to this view is essentially a purposive, explorative, imaginative, and creative enterprise (29). This concept breaks completely with the Skinnerian idea that programed instruction is mainly a process of shaping complex forms of behavior in passive learners by bringing them under many sorts of external stimulus control.

Another interpretation of reinforcement is structured according to the drive reduction theory generally credited to Hull. His theory states that behavior is reinforced because attaining the goal reduces or satisfies the need within the individual. This need may be one of hunger, thirst, or it may be a learned drive such as the need for approval or acceptance (31).

Hilgard (32) indicated the universality of agreement concerning the reinforcement theory:

> At this empirical level there is no important dispute about the validity of the principle of reinforcement, and there is no such thing as a non-reinforcement theorist. Even Guthrie, who is often described as holding a non-reinforcement position, maintains such a view only with respect to the so-called theoretical law of effect.

Reinforcement theory has sprung from laboratory observation and analyses of the learning behaviors of lower organisms. Nevertheless, a projection of its conclusion to human beings provides new insight into the educational problems of teachers, and psychologists alike. Lysaught and Williams (27) list nine generalizations arising from the theory as they pertain to programed learning:

1. An individual learns or changes the way he acts by observing the consequences of his actions.

2. Consequences that strengthen the likelihood of repetition of an act are called reinforcements.

3. The more quickly reinforcements follow the desired performance, the more likely the behavior will be repeated.

4. The more often reinforcement occurs, the more likely the student will repeat the act.

5. Absence or even delay of reinforcement following an action weakens the probability that the act will be repeated.

6. Intermittent reinforcement of an act increases the length of time a student will persist at a task without further reinforcement.

7. The learning behavior of a student can be developed or shaped gradually by differential reinforcement--that is, by reinforcing those behaviors which should be repeated and by withholding reinforcement following undesired acts.

8. In addition to making repetition of an act more probable, reinforcement increases a student's activity, quickens his pace, and heightens his interest in learning. These may be called the motivational effects of reinforcement.

9. A student's behavior can be developed into a complex pattern by shaping the simple elements of the patterns, and combining them into a chainlike sequence.

Historical Background and Evolution of Programed Instruction

Programing for instruction which is regarded as both product and process is part of a long-lived concern with the principles and practices of education and training. In ancient Greece sons of aristocrats and slaves were led step by step through statements that constructed enthymemes and syllogisms, getting cues from leading questions, giving responses in a permissive atmosphere, and gaining immediate feedback. Socrates made attempts at some kind of programing in his dialogues (although there are admittedly crucial differences) (6). Truth was elicited from them in a Socratic version of James Bruner's dictum that any subject can be taught to anybody at any age in some form that is honest (33).

Saettler (34) relates that the concept of programed instruction can be traced back to the Elder Sophists of ancient, pre-Socratic Greece. Furthermore, he gives credit to Maria Montessori as the pioneer of modern programed instruction because of her invention of devices for automating particular teaching functions for children in her Casa dei Bambini in Rome in the first decade of the twentieth century.

Programed instruction for modern times was first conceived and practiced by E. L. Pressey, a psychologist at Ohio State University in 1925. During that year, he exhibited a device anticipating the contemporary teaching machine at the meetings of the American Psychological Association. Pressey described his teaching machine as a simple apparatus which automatically gives and scores tests, and which will also, automatically teach - and teach informational and drill material more efficiently, in certain respects, than the "human machine" (35).

> The writer has also felt that the procedures in mastery of drill and informational material were in many instances simple and definite enough to permit handling of much routine teaching by mechanical means. The average teacher is woefully burdened by such routine as drill and information-fixing.

Pressey's desire to build a machine for automatic testing and teaching grew out of the definite systematization of procedure and objectivity of scoring modern objective test. He further emphasized that even with the modern objective test the burden of scoring was great enough to make insistent the need for labor-saving devices in teaching.

The teaching device exhibited in 1925 had four multiple choice questions and answers in a window, and four keys. If the student thought the second answer was correct, he pressed the second key; if he was right, the next question was turned up. If the second was not the right answer, the initial question remained in the window, and the learner persisted until he found the right one. Meanwhile, a record of all tries was kept automatically.

There are two unique features of this early device that are still unrealized. First, a simple mechanical arrangement made it possible to lift a lever which reversed the action and transformed the machine into a self-scoring, record-keeping, testing device. Secondly, a simple attachment made possible the placing of a reward dial set for any desired goal-score which, if attained, automatically gave the learner a candy lozenge (36).

Meanwhile, Pressey's former student, J. C. Peterson, developed an invisible chemical and later devised "chemo sheets" in which the learner checked his choice of answers to multiple choice questions with a swab, finding that wrong answers immediately turned red and correct ones blue (37).

A "drill" machine was demonstrated by Pressey in 1927 and in 1932 he discussed the advantages of mechanized teaching and scoring devices. He also described a mechanical scoring and tabulating machine. Later Pressey devised a punchboard device and a selective-review apparatus using cards. When using Pressey's punchboard device, the student punched with his pencil through a cover paper. His pencil went deepest when he found the right answer (37). In more recent years, Pressey has urged the use of what he calls adjunct or supplementary auto-instruction which calls for a whole array of instructional media - textbooks, films, and television to be used in conjunction with programed instruction.

Pressey developed a number of other devices and conducted many experiments during the 1920s and 1930s, but their impact on instructional technology was almost inconsequential. Although he discontinued this first phase of his work in 1932 because of the lack of funds, he remained confident that automated instruction would eventually generate an "industrial revolution" in education (38).

Angell and Troyer (39) following the research by Pressey on self scoring devices produced a small punchboard device which the student could use at his desk. When the student punched the paper, if he had selected the correct answer, the pencil went through the paper and a red dot was visible on the scoring key which indicated a correct answer. If when he punched the paper the choice was not correct, it showed an incorrect try. The student knew then that he must select another hole to find the correct answer.

Jensen (40) used the punchboard technique in a laboratory section in which students could come and work with materials and reading assignments used in an educational psychology course. He reported that the students were able to learn the course material at a much faster rate with the punchboards than in regular classroom situations.

These punchboards were used in college classes and found to be effective. The punchboard technique became an effective teaching device because the student could immediately determine whether or not he had the correct answer. If the answer was incorrect, he had the opportunity to keep making choices until the correct answer was found.

Several military training devices constructed in the 1940s and 1950s were developed to teach skills by individualized self-instructional methods. Norman A. Crowder (41) developed a programed instruction approach somewhat similar to Pressey's in the 1950s when he was associated with the United States Air Force and engaged in training trouble shooters to find malfunctions in electronic equipment. Crowder's intrinsic or branch style of programing, as represented in Turtotexts or "scrambled textbooks," consists of steps which contain a limited amount of information, usually less than a page, and a multiple choice question presented at the same time.

Crowder's materials are different from those described for Pressey and Skinner with respect to origin (technical training programs in the armed services), mode of response, and versatility in their use. A frame may be a whole paragraph, presented on a screen of a mechanical tutor, and following the paragraph a question with several possible answers from which the student chooses one by pressing a particular button. If his choice is correct, the next question in order is shown on the screen. But if his choice is wrong, he may be shown explanatory matter and given a subseries of questions designed to explain his error to him.

It is interesting to note that Crowder does not specify nor suggest any particular theory of learning as the basis of his intrinsic programing. However, the techniques of his method can be traced to the assumptions of cognitive theorists. Cognitive theorists are stimulus-centered rather than response-centered. Environmental stimuli are perceived in an organized and structured manner. Learning is a result of relating stimuli to each other in a meaningful way. Facilitation of learning then is accomplished by grouping and presenting stimuli in such a way that they form new cognitive relationships. Sudden insights may result as the new cognitive relationships are formed. Performance is not essential to learning. What the organism does is what he has already learned.

B. J. Skinner is regarded as the father of the contemporary programed instruction movement. In a paper entitled "The Science of Learning and the Art of Teaching" Skinner supplied the first significant impetus to the contemporary programed instruction movement.

Skinner, like Pressey before him, focused attention on the method of presenting programs and called it a "teaching machine." Since the machine rather than the program drew primary attention, more machines than programs were produced during the first years of the movement.

The basic Skinner approach to programed instruction is based on the notion of operant conditioning in which the learner's responses are shaped to pronounce and to write responses correctly and whereby his behavior is brought under various types of stimulus control. Effective Skinnerian or linear programing requires instructional sequences simplified to such a degree that the learner hardly ever makes an error.

Summary of Related Research

A number of studies have been reported in which the effectiveness of programed instruction is compared with the conventional method of teaching. Most of these studies were made using one or more variations of the multiple choice type of program. All studies have concluded that students can learn from programs. The bulk of research studies have reported no significant difference when comparing the two methods of instruction. However, some researchers have taken the no significant difference evidence to mean that programed instruction is a more effective method than teaching in the conventional manner.

Sturlow (42) has discussed the limited number of research studies related to programed instruction. He said that the number of studies reported only scratches the surface and for what he could discern from them is that they are more provocative than definitive. The important question educators have had: Is programed instruction better than traditional instruction? Carr (43) in attempting to answer this question, writes that research in comparing programed instruction with conventional instruction might best be done in the teaching of relatively discrete skills. He gives an example of such subject areas by suggesting the telling of time or the use of Roman numerals.

Porter (44) has related some of the difficulties encountered in doing research involving comparative studies of programed and conventional instructional methods. They are critical of the studies to date because of the lack of sufficient experimental control. They contend that the experimental and control groups have differed in so many respects that it is impossible to tell which of the differences in treatment account for the differences in performance.

A detailed summary of research devoted to program instruction would in itself be a major undertaking. However, this investigator will list and briefly discuss some studies on programed instruction in light of four categories: (1) studies that reflect no significant difference; (2) studies that favor the traditional manner of instruction or that are less assertive in either direction; (3) studies that are favorable toward programed instruction; and (4) studies that reflect programed instruction as being more effective when used as a supplement or as an adjunct to regular textbooks.

1. Geller (45) reported a study on the effectiveness of a teaching machine unit in organic chemistry in a first year college chemistry course. Geller wished to determine whether students could learn the fundamentals of organic chemistry by this method. In a population of 120 students, a random half was taught by a regular instructor; the other one half by a program in a Koncept-o-Graph teaching machine. (The groups were alike in all other aspects,

including homework assignments). Students who used the program learned as much as those who attended the lectures; likewise, they performed similarly on a six-week retention test.

2. An experiment performed at the University of California at Los Angeles by its Department of Engineering faculty compared five different modes of teaching including multiple choice and free response teaching machines, programed textbooks requiring both overt and no overt responses, and programed lectures. They discovered no significant difference in criterion test scores between the teaching methods considered two at a time (46).

3. Eigen (47), in an experiment conducted with eighth grade students, found no significant difference in learning when three modes of presentation were used with the same program. The modes were the Rheem-Didak teaching machines, a horizontal programed textbook and a vertical programed textbook.

4. Griffith (48) investigated the effectiveness of programed instruction as a method of teaching film exposure and flash photography courses. In the eight comparisons between groups receiving directed program instruction and groups receiving non-directed programed instruction, no significant differences were found.

5. Feldheusen and Birt (49) experimented with nine experimental groups of thirty subjects each of which received instructions with nine variations of programed materials to test the hypothesis that there would be no significant difference in learning among the groups. Analysis of covariance was used inasmuch as pretest scores were correlated with the post-test scores which were used to test the

hypothesis. The difference among experimental groups was not significant; thus, the hypothesis was upheld.

6. Hough (50) performed an experiment on 41 students enrolled in the Division of Secondary Education at Temple University taking the course "The Contemporary Secondary School." The content generally covered during the first three weeks of this course surveys historic development of the modern secondary school curriculum. It was this content that was programed for machine teaching. No difference could be found in the achievement of the machine instructed and lecture instructed groups on the post-test.

7. Kellems (51) performed an investigation in which he compared programed materials with materials used in a traditionally taught course in college algebra. The analysis of the post-test scores indicated that there was no significant difference between the means of the experimental and control groups.

The literature on research that has been done on programed instruction shows that the majority of studies indicate no significant difference between the experimental and control groups relative to the dependent or criterion variable. A number of other studies that follows this pattern are (52) (53) (54) (55) (56).

8. Smith (57) carried out an experiment at the United States Air Force Academy and concluded that neither the conventional classroom method of teaching nor programed instruction can produce better learning. However, the study does indicate strongly that the time required to achieve this learning can be reduced through the application of programed instruction.

9. Johnson (58) did a study whereby the hypothesis was rejected because the results revealed that a conventional textbook in algebra is a better choice than a programed one. The results also suggest that programing an entire textbook is not desirable.

10. Milne (59) performed an experiment on the improvement of instruction in chemistry at Washington State University. It is interesting to note that the results he obtained showed that for recall of information no conclusion could be drawn as to the most effective method of presentation, that for application of principles the experimental was significantly better than the conventional, and for problem-solving the conventional tutorial method was significantly better than the experimental method.

Consistent with this writer's earlier decision to relate some of the findings in the recent literature on programed instruction by categories, the category of those studies that reflect results that "favor" program instruction is now considered.

11. The results of Barnes' (60) study on comparison of programed lectures and the ones presented in the traditional manner are indicative of the fact that students achieve at a higher level when programed lectures are used and in some cases this level is significantly higher than that attained by a similar group traditionally taught.

12. Walsh (61) experimented with programed instruction on groups of high school students to teach them high school chemistry with rates of reaction and chemical equilibrium. The members of the experimental group achieved at a significantly higher level than did the members of the control group.

13. Goldberg (62) and his associates experimented with comparable groups of clerical employees who were taught descriptive statistics by three different instructional methods. Although there was no significant difference in achievement test scores, the researchers ruled in favor of programed instruction. This researcher surmises that their rationale to favor programed instruction was due to the time saved during the training period in an industrial setting.

14. Otting (63) made a study on social studies classes using programed materials to replace the textbook and compared them with conventionally taught courses in order to ascertain the effectiveness of programed instruction as a teaching tool. The results at two of the schools involved in the study indicated a significant advantage for the programed groups. In two other schools, the test results indicated an advantage for the control groups although the differences were not significant.

The number of studies that favor programed instruction ranks second to the studies that indicate no significant difference as their results. These studies (64) (65) (66) (67) lend further support to programing instruction being a superior method of instruction to the conventional method of instruction.

As stated earlier, Pressey was perhaps the first investigator to give a discussion on the meaning of adjunct auto-instruction. He stated that adjunct auto-instructional procedures are designed to clarify and extend meanings, to correct misunderstandings, to confirm the students' choice, to point out his errors, and guide him to the correct answers.

Pressey and Kinzer (16) have written:

> Adjunct auto-instruction assumes that the student has some understanding of the task and that he has already made some effort to deal with it, that he has read some textbook material, listened to a lecture, or has participated in some relevant activity. Adjunct auto-instruction does not substitute for a text nor eliminate the instructor. It assumes, and there is much evidence to support the assumption, that much material can be learned more economically, just by reading and that in this reading not only does the student derive information and understanding but he becomes aware of the purpose of the discussion, and something of the structure of the exposition. Then with much already being understood, adjunct auto-instruction will aid on the elements of greater difficulty.... Adjunct auto-instruction will be used, then in situations where the student is an active participant in what is to him a meaningful learning experience. It will aid him as a good teacher does. It will not displace the teacher but will help him to put his efforts at those points where clearing up of major difficulties and where extended meanings will yield greatest results.

Some studies that emphasize that programed materials can be most effectively used as supplements or adjuncts to a good text follow:

15. Brown (68) during an experiment on using program materials as supplemental instruction in college physical science arrived at the conclusion that such programed materials may be effective as supplemental instruction. Another one of his conclusions was that such materials are desired by students.

16. The research which Pressey and Kinzer (16) have been pursuing at the University of Arizona indicates that students at the college and high school levels do learn from supplementary programed materials better than by more conventional methods.

17. Evans, Glazer, and Homme (69) have pointed out that the small experimental literature presently available on the efficiency of programed characteristics may be summarized as follows: multiple-

choice devices which provide immediate knowledge of results can be used effectively to supplement regular classroom instruction.

18. Love (70) writes that programed materials provided a supplement to televised instruction which was more effective than either a classroom discussion method or a televised problem session. The latter two methods did not differ significantly in effectiveness.

19. Fejfar (71) insists that it would seem that programed booklets could be used to supplement and perhaps even supplant regular instruction in such a way that would allow for and develop individual differences. Further, he states that because of the magnitude of some of the unresolved problems which pertain to programed instruction, however, it may be that booklets developed according to an inductive method are best suited to make an initial contribution as supplementary educational materials.

In a symposium sponsored by the American Chemical Society under the direction of J. A. Young on programed instruction in chemistry, all of the speakers were convinced, strongly so, that programed instruction is a useful teaching tool. They emphasized that when programs are used as adjuncts to a good text in elementary chemistry, the students tend to be weaned away from the programed instructions rather quickly. They learn from the examples set by the programs how to extract information from the text for themselves. One might say that, at least, they have learned how to read intelligently, while asking questions of the author and providing their own answers (17).

Leith (72) reviewed the literature on effectiveness of programed versus comparable regular material. He concluded that programed texts save time over conventional texts but do not lead to better performance on a content examination. One of the few consistent findings in the research on programed materials was that learning, as measured by an examination, is about the same for the programed and conventional materials. However, the failure to demonstrate greater effectiveness for the programed over the conventional materials may be due to methodological weaknesses in the previous research.

A search of the recent literature on programed instruction revealed only one study (73) that made use of the technique of matched grouping. It is this writer's opinion, however, that such a technique has relevance for further interpreting and analyzing the influence of an adjunct to a regular adopted text. This investigator's high regard for matched grouping as a research technique is further supported by Borg (74), Mouly (75), Garrett (76), and Sax (77).

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

Chemistry 1015 is a five semester-hour general chemistry course taught at Oklahoma State University for non-chemistry majors. The classes meet three times weekly in fifty minute periods each for lecture and one three hour session per week for laboratory practice. In addition, weekly one hour quiz sessions are taught by graduate assistants; these sessions are generally reviews of theory materials considered in previous lecture sessions.

The textbook currently in use for the course is College Chemistry, fifth edition, by King and Caldwell (78), of which eighteen chapters, though not in numerical sequence, are studied during the semester. These are (Appendix A):

Chapter 1. Introduction

Chapter 2. Fundamental Principles

Chapter 3. Atoms and Subatomic Particles

Chapter 4. Structure of Atoms

Chapter 5. Classification - Elements Periodic Table

Chapter 6. Formulas and Equations

Chapter 10. Valence

Chapter 11. Chemical Bonds

Chapter 12. Classification of Compounds and Nomenclature

Chapter 15. Stoichiometry

Chapter 7. Oxygen

Chapter 8. Hydrogen

Chapter 9. Gaseous States of Matter

Chapter 13. Water and Liquid State

Chapter 14. The Solid State

Chapter 17. The Halogens

Chapter 22. Nitrogen and the Atmosphere

Chapter 23. Nitrogen Compounds

The laboratory manual being used is Semi-Micro Laboratory Exercises in General Chemistry, third edition, by Burrows, Arthur, and Smith (79), from which the following schedule is arranged (Appendix A):

Experiment 3. Physical and Chemical Changes

Experiment 4. Conservation of Mass (½ first lab practice)

Experiment 4. Concluded

Experiment 9. Law of Definite Proportions

Experiment 10. Displacement Reactions

Experiment 8. Oxygen

Experiment 11. Hydrogen

Experiment 13. Water and Experiment 14, Hydrates

Experiment 12. Equivalent Weights and Valence

Experiment 31. Chlorine and

Experiment 32. Hydrogen Chloride

A second course, Chemistry 1225, follows Chemistry 1015 and continues with the same textbook and laboratory manual that were used in Chemistry 1015. The involvement of Chemistry 1225 in the present study will be only to determine the further use of the supplementary programed materials ~~that were used in Chemistry~~ 1015.

The Research Design and Procedure

An equivalent group design was used for this study. This is the most common type of experimental design in education. Cook (80) has stated that in its simplest form it consists of two groups of subjects which are equated on all the relevant variables. One group, called the experimental group, is exposed to the experimental treatment. The other group, the control group, receives no treatment. If the difference is not statistically significant it is attributed to chance. There are various ways in which groups are made equivalent. The three are (1) random selection, (2) matching, and (3) statistical techniques. In this study this writer made use of the three techniques as attempts to make equivalent groups, thusly giving added strength to the statistical analysis and research findings. The random selection technique was used to designate subjects for the experimental and control groups, the matching technique was used to set up matched groups based on American College Testing Program composite standard scores and the cumulative test scores. Analysis of covariance was the statistical technique used in two instances when the ACT scores were used as a covariable with cumulative and MAT scores. T-tests were used for the matched groups. Chi square analysis and proportions of responses expressed as percentages were the statistical techniques used for analysis of responses to two questionnaires used to collect data in Chemistry 1015 and in Chemistry 1225. These statistical techniques will be discussed in a later section in this chapter.

In addition to equating groups on the basis of random selection, matching, and a statistical technique additional controls were used in structuring the use of the programed materials by the experimental group. To be sure that each subject of the experimental group received the same instruction regarding the use of the programed materials, directions were written by this researcher and the graduate teaching assistants read them to the students in lab-quiz section periods the first time the sections met to begin the fall semester. The directions included cautioning the students not to depend on the programed materials alone, indicating the three most important volumes out of the set of five, reminding them that the programed supplements were to be read outside of the class, and to be sure to use the materials, but that they were not to be loaned to other students.

The Study Population and Sample

The students who enroll in Chemistry 1015 represent several of the colleges within the university and all of the undergraduate classifications. Only freshmen and sophomores were included in the sample. Tables I and II show the distribution of students according to college and classification.

The entire enrollment of 533 students in Chemistry 1015 sections at Oklahoma State University during the 1968 fall semester was the population for this study. They were accommodated in four large lecture sections and in twenty laboratory sections. Two laboratory-quiz sections of Chemistry 1015 were randomly selected for the experimental group, and designated as sections one and two and assigned to graduate assistants leaving six laboratory quiz sections for the control group. The formal lectures were given by three professors on the staff of the Department of Chemistry.

TABLE I

DISTRIBUTION OF STUDENTS BY COLLEGE

College	Number	% of Grand Total
Agriculture	102	32.00
Arts and Sciences	91	28.00
Business	3	0.93
Education	11	3.40
Engineering	57	17.80
Home Economics	57	17.80
TOTAL	321	

TABLE II

DISTRIBUTION OF STUDENTS BY CLASSES

Classification	Number	% of Grand Total
Freshman	231	72
Sophomore	90	28
TOTAL	321	

It was assumed that there was random distribution in the four sections due to enrollment procedures at Oklahoma State University. This assumption was based on the procedure by which students are invited to the University four days a week each week during the summer for enrollment purposes. At this time each student is assigned to an advisor, who in turn assigns the student to a section without regard to any assignment criteria.

To add strength to the randomization process, the registration numbers of the 533 enrollees were placed in a box followed by drawings during which every other one was discarded in order to increase the number of drawings from the population. The even numbers that were kept by this investigator during the drawing procedure made up the experimental group of 175 subjects leaving 358 subjects for the control group. Due to classifications other than freshman or sophomore and withdrawals during the course of the semester, 321 subjects were left for consideration in the study of which 114 were in the experimental group and 207 were in the control group.

At the end of the semester this writer obtained the cumulative test scores for subjects in the experimental and control groups and constructed matched groups using ACT scores with an interval of five to obtain maximum homogeneity within groups (81). The matching technique was completed by inserting the cumulative test scores for the groups in the intervals that included their corresponding ACT scores (Table III). One score each from the experimental and control groups was discarded in the interval 10-6 because the matched group technique could not be applied to a matched pair.

TABLE III

THE NUMBER OF CUMULATIVE SCORES USED TO FORM MATCHED GROUPS FOR THE EXPERIMENTAL (GP_1) AND CONTROL (GP_2) GROUPS

Experimental (GP_1)	Intervals	Control (GP_2)
10	30–26	11
41	25–21	66
49	20–16	102
13	15–11	27

The Programed Materials

Young (17) has stated that comprehensive knowledge of any topic is ordered in textbooks in terms that are appropriate to the subject rather than the student; it is clear, therefore, that programed instruction should be an adjunct, a supplement for beginners. The programed materials this writer chose to supplement the adopted textbook for Chemistry 1015 were authored by Virginia Powell (82). This group of programed materials is available as a set of five.

"Chemical Symbols" discusses the symbols of the common elements, inserting here and there a bit of interesting descriptive chemistry. Regard for the student is evident, for example, in the caution concerning possible confusion between manganese and magnesium. This is not a drill program; the necessary drill to memorize the symbols is recommended as a separate activity to the student.

"Chemical Formulas and Names" is an extensive development of the formulas and names of the more common inorganic compounds, also involving the use of valence. The Stock Nomenclature is used, with a brief mention of "-ous" and "-ic" as archaic suffixes, but necessary to know.

"Molecular Weight Calculations" begins with a simple dimensional analysis, then significant figures are defined and rules for their proper use explained. Formula weights and molecular weights (distinguished in terms of covalent versus ionic compounds) are treated, then the concept of per cent, which is applied to calculation of per cent composition from the formulas of a compound. Exponential notation is described and Avogadro's number identified. The gram atom, gram molecule, and mole are defined as synonymous with examples. Empirical formulas are calculated from per cent composition.

In "Weight and Volume Relationships" the mole is defined as the number 6.02×10^{23}, and typical stoichiometric problems are solved using this concept, but by using a scheme of number arrangement reminiscent of the now disparaged proportion method. Some reactions with gaseous reagents or products are used as examples, but in these cases, the temperature and pressure are implicitly held constant, often under "STP."

"Balancing Chemical Equations" is exactly this. It begins with reactions in which there is no change in oxidation state, and proceeds through net ionic reactions, the determination of oxidation number, redox reactions (by the half-equation method), and ends with the "balancing" of nuclear equations.

The programed supplements entitled "Chemical Symbols," "Chemical Formulas," and "Molecular Weight Calculations" were the most important volumes for the topics that were indicated on the departmental study guide (Appendix A) for Chemistry 1015, however, use was made of the five volumes to some extent. This investigator realized that the programed booklets contained many items that would not be considered in Chemistry 1015, hence it would not benefit the student to read them in their entirety. Therefore, a supplementary study guide was prepared (Appendix B) by starting with Chapter 3 in the textbook and indicating for each chapter the appropriate frames to be studied and the volumes that contained these frames which were labeled Volume A through E.

The Measuring Instruments

Four instruments were used in the study. The first, the American College Testing Program (ACT Battery) which is a battery of tests over the four basic subject matter areas (English, Mathematics, Social Studies, and Natural Science) for prospective college freshmen. For this study use was made of ACT Composite Scores which is the average of the standard scores for the four tests of educational development included in the ACT Battery. These tests assess the student's ability to perform academic tasks typically required by college courses. The tests have been shown to be as predictive of college grades as other tests of academic potential.

The second instrument used consisted of the cumulative test scores in Chemistry 1015 for the fall semester 1968. The scores were computed from two one-hour examinations and the final examination which were administered to all lecture sections (Appendix C). The common examinations were intra-departmental ones prepared jointly by the instructors who gave the lectures.

The cumulative test scores on the Minimum Attainment Tests were the third instrument used in the study. The scores were computed from three Minimum Attainment Tests that were given during the semester (Appendix D). These tests were prepared by the instructors who gave the lectures from study sheets that had been given to each student in Chemistry 1015. The purpose of the MAT is to measure the minimal progress of students in Chemistry 1015 at specific intervals during the semester.

Two questionnaires were used to gather information concerning the use of the supplementary programed materials. The first questionnaire was presented to all students enrolled in Chemistry 1015 during the last week of the fall semester (Appendix E). On this questionnaire the students were asked if they were aware that the material taught in Chemistry 1015 was available to be studied in programed form. If the response was yes, the student was asked to rate a number of aspects of the presentation such as how frequently he used the programed supplements and how he became aware of the existence of these materials. The second questionnaire (Appendix E) was presented to students enrolled in Chemistry 1225 after two weeks in the spring semester in order to determine the extent to which the programed materials in Chemistry 1015 were currently being used. Complete anonymity was maintained in an attempt to achieve the unbiased opinions of the students.

The tabulated results of the questionnaires will be included in Chapter IV which is concerned with the results of the study.

The Statistical Treatment

The statistical techniques used to determine the significance of the results of this study were analysis of covariance on the experimental and control groups, in each of two analyses the ACT Composite Standard Scores served as a covariate with the cumulative tests and MAT scores. Chi-square analysis and proportions of answers expressed as percentages were made on each of two questionnaires, respectively. A t-test for matched groups was employed as a statistical technique and the acceptance level was set at the 0.05 level of significance.

Data for the experimental and control groups and the matched groups were prepared for the Oklahoma State University Computing Center. The analysis of covariance program was utilized in the IBM 360 Computer System, Model 50. This program calculates F ratio for the adjusted means, Beta coefficients and their standard errors and t-values, and the adjusted treatment means and their accompanying standard errors.

In his description of the Analysis of Covariance, Garrett (83) stated:

> Analysis of covariance represents one extension of analysis of variance to allow for the correlation between initial and final scores. Covariance analysis is especially useful to experimental psychologists when for various reasons it is impossible to or quite difficult to equate control and experimental groups at the start; a situation which often obtains in actual experiments. Through covariance analysis one is able to effect adjustments in final or terminal scores which will allow for differences in some initial variable.

Cook (80) has written that in the analysis of covariance actually, groups are not equated in this technique, but the statistical procedure enables the researcher to take into account in his data analysis the effect of differences between the groups on the variable he wants held constant. To put it another way, the uncontrolled variables are held constant statistically. This enables the investigator to carry out his experiment with the precision necessary for a meaningful interpretation of the results.

The chi-square test, in addition to being a nonparametric test, was suitable for the questionnaire data of this research because it deals with frequencies which were placed in distinct categories.

Popham (84) has written that a nonparametric technique which may be used to test the difference between the distribution of one sample and some other hypothetical or known distribution is the chi-square test. The chi-square test can be used with data measured on nominal or stronger scales. Essentially, this procedure involves a "goodness of fit test" wherein the sample frequencies actually falling within certain categories are contrasted with those which might be expected on the basis of the hypothetical distribution. If a marked difference exists between the observed or actual frequencies falling in each category and the frequencies expected to fall in each category on the basis of chance or a previously established distribution, then the chi-square test will yield a numerical value large enough to be interpreted as statistically significant.

The chi-square test requires that the expected frequencies in each cell should not be too small. This does not mean that the observed or actual frequencies should not be too small; reference is made only to expected frequencies. When this requirement is not met, the result of the test is meaningless. However, the term "small" has not been uniformly defined. Walker and Lev (85) suggest that if there are two or more degrees of freedom and roughly approximate probabilities for the test of significance, an expectation of only two in a cell is sufficient. Snedecor and Cochran (86) state, "the chi-square test is accurate enough for single classification if the smallest expectation is at least 1."

The t-test was the statistical technique employed on the matched groups. The t-test is used to determine how great the difference between two means must be in order for it to be judged significant, that is, a significant departure from differences which might be expected by chance alone. Popham (84) has stated that the function of the t-test is to test the null hypothesis that two group means are not significantly different, that is, the means are so similar that the sample groups can be considered to have been drawn from the same population.

Summary

This chapter has been a consideration of the description of the course, students, and materials studied in Chemistry 1015. Further, it considered the research design, the population and the sample, the programed supplements, the measuring instruments and the statistical treatment.

Chemistry 1015 is a general chemistry course taught the fall and spring semester each year to nonchemistry majors. Chemistry 1225 is a course that follows Chemistry 1015 in which the same textbook and laboratory manual are used. Data for this study was collected during and at the end of the course that began in September, 1968, and ended in January, 1969. The investigation was conducted to determine if there is any significant difference in achievement by students who were enrolled in Chemistry 1015 in which one group, the experimental group, received the treatment of supplementary programed materials and the control group did not receive subject treatment.

In the next chapter a presentation will be given of the findings secured from questionnaires that were submitted to students in Chemistry 1015 and Chemistry 1225 and the statistically analyzed results.

CHAPTER IV

RESULTS AND FINDINGS

During the first semester of the academic year, 1968-69, an investigation was conducted to reveal the effect of using supplementary programed materials (as adjuncts to a chemistry textbook) on the achievement of freshman and sophomore students enrolled in Chemistry 1015 at Oklahoma State University. For the study, two laboratory-quiz sections of Chemistry 1015 were randomly selected for the experimental group and six laboratory-quiz sections provided the control group.

The population, according to the designation previously described, that is, those who were freshmen and sophomores, consisted of 321 students of whom 114 were in the experimental group and 207 were in the control group.

The analysis of data concerning the achievement of students in Chemistry 1015 is presented in this chapter. Analysis of covariance to test the significance of the difference in means between the two methods of instruction was used as a statistical technique. Other statistical methods employed were t-test for matched groups, chi-square analysis on frequency counts of responses on a questionnaire, and proportions of answers on a second questionnaire expressed as percentages.

Testing Hypotheses by Analysis of Covariance

To test the significance of difference in means between the supplementary programed and traditional methods of instruction, covariance analysis was used. Analysis of covariance, by incorporating elements of the analysis of variance and regression, provides a test of significance for comparison of groups, with a covariable as a control placed on the differences of a variable known or suspected to influence the dependent or criterion variable. In both analyses the covariable was the ACT Composite Scores, the cumulative and MAT scores being criterion outcomes to test the hypotheses that were stated in the null. The results of analysis of covariance are summarized in Tables IV and V.

TABLE IV

ANALYSIS OF COVARIANCE OF EXPERIMENTAL AND CONTROL CHEMISTRY STUDENTS' ACHIEVEMENT PERFORMANCE ACT AND CUMULATIVE SCORES (COVARIATES)

		Residuals		
Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Between	1	1.5625	1.5625	0.001*
Within	318	449,027.3125	1412.0354	
Total	319	449,028.8750		

*Not significant beyond the 0.05 level.

TABLE V

ANALYSIS OF COVARIANCE OF EXPERIMENTAL AND CONTROL CHEMISTRY STUDENTS' ACHIEVEMENT PERFORMANCE ACT AND MAT SCORES (COVARIATES)

Residuals				
Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Between	1	133.8750	133.8750	0.933*
Within	318	45,628.2891	143.4852	
Total	319	45,762.1641		

*Not significant beyond the 0.05 level.

I-a. There is no significant difference in cumulative test scores due to the use of supplementary programed materials compared with the conventional methods of instruction among freshman and sophomore students of Oklahoma State University enrolled in Chemistry 1015.

The computed value of 0.001 was less than the F value of 3.87 required for significance (1 and 318 degrees of freedom), therefore, the writer failed to reject the null hypothesis.

I-b. There is no significant difference in minimum attainment test scores due to the use of supplementary programed materials compared with conventional methods of instruction among freshman and sophomore students of Oklahoma State University enrolled in Chemistry 1015.

The F value obtained of 0.933 was less than the F value of 3.87 required for significance (1 and 318 degrees of freedom), therefore, the writer failed to reject the null hypothesis.

The results of the analysis of data show that there are no significant differences in cumulative test and minimum attainment test scores when groups, experimental and control, are adjusted for differences in ACT Composite scores.

The t-values for testing the significance of the slope of regression of cumulative test and minimum attainment test scores on ACT scores were computed as a part of the analysis of covariance. The results are summarized in Table VI.

TABLE VI

SUMMARY OF DATA FOR COMPUTATION OF T-VALUES

Regression	Source	d.f.	t	Significance at 0.05 Level
ACT-CUM	Error Within	1318	6.7496	Yes
ACT-CUM	Total Error	1319	6.7763	Yes
ACT-MAT	Error Within	1318	5.5819	Yes
ACT-MAT	Total Error	1319	5.6712	Yes

The t-values were significant at the 0.05 level of confidence, therefore, the decision to use ACT scores as a covariate with cumulative test and MAT scores appears to be justified by the significance of the regression between these items.

Results of t-Tests for Matched Groups

The t-test technique was employed to test the following hypothesis:

I-c. There is no significant difference in achievement in Chemistry 1015 when matched groups are compared on cumulative test and ACT scores over intervals of five.

A t-value was computed for each of four matched groups. This test was used to compare the means of two groups to determine whether or not the difference (between the means) is sufficient to assume that the groups actually represent two different populations. The results are summarized in Table VII.

TABLE VII

SUMMARY DATA FOR COMPARISONS OF MATCHED GROUPS

Interval	(Experimental) Group Mean	Sample Size	(Control) Group Mean	Sample Size	d.f.	t
5	127	10	125.636	11	19	0.12152*
5	100.537	41	99.9394	66	105	0.07069*
5	81.1224	49	79.8333	102	149	0.21951*
5	65.9231	13	74.4815	27	38	0.64597*

*Not significant at the 0.05 level of confidence.

The t-values obtained were less than the tabulated t-values of 2.093, 2.00, 1.98, and 2.04, respectively, required for significance at the degrees of freedom indicated. The writer failed to reject the null hypothesis, "there was no significant difference in achievement in Chemistry 1015 when matched groups were compared on cumulative test and ACT scores over intervals of five."

By observing the data in Table VII, one can detect that the means of the first three comparisons are in favor of the experimental groups, however, not to the degree of statistical significance. Also, the means of the groups in each paired group are closer to each other than they are to the means of the next paired group. Since all t-values were not statistically significant it is evident that the groups came from the same population.

Results of Analyses of Questionnaires Relative to Programed Materials Usage

It was described on page 45 how two questionnaires were used to collect data on the use of supplementary programed materials in Chemistry 1015 during the fall semester and in Chemistry 1225 during the spring semester of the academic year 1968-69.

The first questionnaire was given to all students who were enrolled in Chemistry 1015 during the fall of 1968. The first question listed on the questionnaire was: "Are you aware that the material taught in Chemistry 1015 is available to be studied in programed form?" If the respondent's answer was "no" it was made known to the student through written directions that it was not necessary to complete the remainder of the questionnaire. However, if the respondent's answer was "yes" the student was directed to continue with the completion of the questionnaire by choosing an answer from each of five questions that contained multiple-choice answers, the best answer to the question as the respondent discerned it. While anonymity was maintained, students were directed to indicate their college classifications. There were 501 students who responded to the questionnaire out of which 132 students indicated "yes" answers and 369 students indicated "no" answers to the question. Being consistent with the limitation of this study to underclassmen, 21 of the "yes" responses were discarded because those respondents indicated classifications other than freshman and sophomore, leaving 111 subjects' responses for further consideration by statistical technique.

Chi-square analyses were used to test the following hypotheses and the results are summarized in Tables VIII through XIII.

II-a. There is no significant difference in the number of students who knew and those who did not know about the availability of programed materials to supplement the textbook used in Chemistry 1015.

A chi-square analysis of the number of students who did or did not know about the availability of programed materials to be used as a supplement is presented in Table VIII.

TABLE VIII

A CHI-SQUARE ANALYSIS OF THE AWARENESS OF THE AVAILABILITY OF PROGRAMED MATERIALS FOR CHEMISTRY 1015

	Yes	No
Observed Responses	111	369
Expected Responses	240	240

$x^2 = 137.6$ d.f. = 1 $0.05 > P$

A table of critical values revealed that the chi-square value required for significance was 3.84 (with 1 degree of freedom), therefore, the writer rejected the null hypothesis. The alternate hypothesis, "there was a significant difference in the number of students who knew and those who did not know the availability of programed materials to supplement the textbook used in Chemistry 1015," was accepted.

II-b. There is no significant difference in the number of students who used supplementary programed materials frequently, occasionally, very, very little, did use but less than five times, or none at all.

This hypothesis was tested by a chi-square analysis as is shown in Table IX.

TABLE IX

A CHI-SQUARE ANALYSIS OF THE FREQUENCY OF USE MADE OF PROGRAMED MATERIALS IN CHEMISTRY 1015

	Frequently	Occasionally	Very Little	Did Use but < 5 Times	Did Not Use
Observed Responses	19	36	24	23	9
Expected Responses	22.2	22.2	22.2	22.2	22.2

$x^2 = 17.05$ d.f. = 4 $0.05 > P$

The chi-square value required for significance at 0.05 is 9.488, therefore, the null hypothesis was rejected. The alternate hypothesis, "there was a significant difference in the number of students who used programed materials frequently, occasionally, very little, very, very little, or none at all," was accepted.

II-c. There is no significant difference in the number of students who became aware of the existence of supplementary programed materials through the instructor's advice, fellow students, the library, or the bookstore.

This hypothesis was tested by a chi-square analysis as is shown in Table X.

TABLE X

A CHI-SQUARE ANALYSIS OF THE SOURCE OF AWARENESS OF PROGRAMED MATERIALS FOR CHEMISTRY 1015

	Instructor	Fellow Students	Found in Library	Purchased in Bookstore
Observed Responses	104	2	0	5
Expected Responses	27.75	27.5	27.5	27.5

$x^2 = 281.20$ d.f. = 3 $0.05 > P$

From the data presented, the writer rejected the null hypothesis. The alternate hypothesis, "there was a significant difference in the number of students who became aware of the existence of programed instructional materials through the instructor's advice, fellow students, the library, or the bookstore," was accepted.

II-d. There is no significant difference in the number of students whose study time for Chemistry 1015 was shortened, lengthened, or was not affected by the use of supplementary programed materials.

This hypothesis was tested by a chi-square analysis as is shown in Table XI.

TABLE XI

A CHI-SQUARE ANALYSIS OF THE EFFECT OF PROGRAMED MATERIALS ON STUDY TIME

	Shortened the time	Lengthened the time	Had No Effect
Observed Responses	20	43	48
Expected Responses	37	37	37
$x^2 = 12.04$	d.f. = 2		$0.05 > P$

The chi-square value required for significance is 5.99, therefore, the writer rejected the null hypothesis. The alternate hypothesis, "there was a significant difference in the number of students whose study time for Chemistry 1015 was shortened, lengthened, or was not affected by the use of supplementary programed materials," was accepted.

III. There is no significant difference in the number of students that enrolled in Chemistry 1015 who favored supplementary programed materials, or teacher conference, or the textbook as the most valuable learning aid for the course.

This hypothesis was tested by a chi-square analysis and the results are summarized in Table XII.

A table of critical values revealed that the calculated value of 27.4 was significant at the 0.05 level of confidence, therefore, the writer rejected the null hypothesis. The alternate hypothesis, "there was a significant difference in the number of students that enrolled in Chemistry 1015 who favored supplementary programed materials, teacher conferences, or the textbook as the most valuable learning aid for the course," was accepted.

TABLE XII

A CHI-SQUARE ANALYSIS OF THE NUMBER OF STUDENTS WHO FAVORED PROGRAMED MATERIALS, TEACHER CONFERENCES, OR THE TEXTBOOK

	Programed Materials	Teacher Conferences	Textbook for the Course
Observed Responses	15	36	60
Expected Responses	37	37	37

$x^2 = 27.4$ d.f. = 2 $0.05 > P$

IV. There is no significant difference in the number of students enrolled in Chemistry 1015 who indicated that they liked, did not like, or had no feeling relative to the use of supplementary programed materials for the course.

A chi-square analysis was used to test this hypothesis and is summarized in Table XIII.

The chi-square value required for significance was 5.991, therefore the writer rejected the null hypothesis. The alternate hypothesis, "there was a significant difference in the number of students enrolled in Chemistry 1015 who indicated that they liked, did not like, or had no feeling relative to the use of supplementary programed materials for the course," was accepted.

TABLE XIII

A CHI-SQUARE ANALYSIS OF THE NUMBER OF STUDENTS WHO LIKED, DID NOT LIKE, OR HAD NO FEELING AT ALL CONCERNING PROGRAMED INSTRUCTION

	Liked	Did Not Like	No Feeling at all
Observed Responses	60	12	39
Expected Responses	37	37	37
x^2 = 32.66		d.f. = 2	0.05 > P

The second questionnaire was presented to all students enrolled in Chemistry 1225 two weeks after the beginning of the spring semester in order to determine the extent to which the supplementary programed materials, designated for use in Chemistry 1015, were currently being used. In other words, to ascertain the degree to which programed materials had "caught on" as adjuncts to the adopted chemistry textbook. Out of a total of 192 students who responded to the questionnaire, 46 (24 per cent) indicated that they had made use of the supplementary programed materials in Chemistry 1015, but only 6 (13 per cent) of that number continued to use the programed supplements in Chemistry 1225. One hundred forty-six (76 per cent) of the students who completed the questionnaire indicated that they did not use the supplementary programed material in Chemistry 1015. The writer observed that most of these students had not been enrolled in Chemistry 1015 during the previous fall semester. Four of the students who answered "no" to the question indicated that they were making use of the supplementary programed materials in Chemistry 1225.

Summary

This chapter has presented the findings of the present investigation resulting from the comparison of supplementary programed instruction with conventional methods of teaching Chemistry 1015 as interpreted according to the (a) analysis of covariance, (b) t-test, (c) chi-square, and (d) proportions of responses expressed as percentages. The statistical analysis of the study involving achievement in chemistry failed to show a significant difference between the control and experimental groups but did show a trend favoring the experimental group.

The writer rejected six hypotheses that were formulated on a questionnaire items presented to students in Chemistry 1015 resulting from chi-square analysis. From results of a second questionnaire presented to students in Chemistry 1225 programed supplements that were used in Chemistry 1015 were not well-received or that they had not "caught on" as adjuncts to the adopted textbook.

Chapter V will present the summary, conclusions, and recommendations of the study based on these findings.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to investigate experimentally the effectiveness of using supplementary programed materials as adjuncts to an adopted textbook in elementary chemistry on student achievement in general chemistry at Oklahoma State University. With this view in mind programed booklets were made available as a set of five for subjects in the experimental group in the University's bookstore. The five booklets, authored by Virginia Powell, are entitled "Chemical Symbols," "Chemical Formulas and Names," "Molecular Weight Calculations," "Weight and Volume Relationships," and "Balancing Chemical Equations." The researcher supplied the students in the experimental group with a supplementary study guide in order that their study in the programed booklets would be consistent with the departmental study guide for Chemistry 1015.

The subjects of the investigation were freshman and sophomore students enrolled in Chemistry 1015 during the fall semester of the academic year 1968-69. The experimental group of 114 subjects made use of the supplementary programed materials as adjuncts to the adopted chemistry textbook. The control group received regular classroom instruction from the textbook only. Chemistry 1015 lectures were given by three professors on the staff of the Department of Chemistry.

The study involved eight lab-quiz sections taught by graduate teaching assistants. These sections are one hour weekly reviews of chemical principles and calculations that have been covered earlier in the regular lecture periods.

Analysis of covariance was utilized to test the major null hypothesis which was that there will be no significant difference in achievement scores due to the use of supplementary programed materials compared with the conventional method of instruction among underclassmen relative to (a) ACT scores and cumulative test scores, (B) ACT scores and MAT scores, and (c) matched groups and cumulative test scores matched with ACT scores over intervals of five. The "t" statistic was used to test the significance of the slope of regression of cumulative and minimum attainment test scores on ACT scores as part of the covariance analysis. The "t" statistic also was utilized to compare the mean achievement scores for each of four matched groups. Chi-square analysis was used to test six null hypotheses that were formulated from items on a questionnaire. The statistics for a second questionnaire were proportions of responses expressed as percentages.

An opinion survey was made to obtain feelings of students toward supplementary programed materials also to determine the extent to which they made use of the supplements.

Conclusion

It was not surprising to the investigator that the study failed to show statistically significant difference between the experimental and control groups' mean achievement scores since most research results on programed instruction, whatever the mode of presentation may be, support this view. It should be noted, however, that there was a trend favoring the experimental group in the covariance analysis and t-tests results. It was concluded that there is no significant difference in achievement in Chemistry 1015, as measured by test scores, when groups are adjusted for differences in ACT scores. Further, it was concluded from the t-test results on matched groups since all four tests showed no significant difference when comparing the means of two groups that the groups came from the same population.

From the investigator's experience in teaching chemistry to non-chemistry majors over a period of years, he was surprised at the responses that were made to questions on the questionnaire presented to students in Chemistry 1015. The writer has observed that non-chemistry majors gladly accept suggestions and seek out means to improve their chance of success in required chemistry courses.

The number of students who knew about the availability of programed supplements for Chemistry 1015 gives evidence of adequate control of the use of the materials. Only 19 of 111 subjects who used the programed supplements indicated that they had used the materials "frequently" and 36, the largest number of students, used them "occasionally." The writer views the reason for this condition to be that the use of supplementary programed materials was auto-instructional in nature; the students read on their own outside of the classroom. Since the number of students who were aware of the availability of programed materials exceeded the number of students in the experimental group by only 22, evidently they were made aware of the existence of the supplementary programed materials through the instructor, that is, the graduate teaching assistant. The data on the effect of programed materials on study time show consistency in that the 19 students who used the supplements frequently were overshadowed by 20 students who indicated that their study time was shortened. It is obvious that had more students used the supplements the less time would have been required for chemistry study and, perhaps, the students could have spent more time on another subject which could have improved their grades generally. On the question of which was favored as the most valuable learning aid, 60 students indicated the textbook for the course, 36 students indicated teacher conferences, and 15 students indicated their preference for programed materials, again showing consistency with the 19 students who used the materials frequently and the 20 students who indicated that it shortened their study time. As an afterthought, the investigator realizes that since programed materials and textbooks are teaching tools, teacher conferences were not a good item in the trio of multiple-choice selections. The final questionnaire item presents a paradox in that 60 students indicated they liked the programed supplements, 12 students who did not like them, and 39 who indicated no feeling at all concerning programed instruction. This item is inconsistent with the previous ones, showing 60 students liked the supplementary programed materials. The writer deems from this that students liked it but did not know how or just did not make use of the supplements.

The following conclusions are presented in terms of the stated purpose of the study and the observed influence of the supplementary programed materials on the experimental group.

1. Supplementary programed materials can be successfully used as adjuncts to a good adopted textbook in chemistry with no loss in achievement.

2. Students achieve higher group mean scores on cumulative and minimum attainment tests when supplementary programed materials are used in general chemistry.

3. More than one half of the students in the experimental group indicated that they liked programed supplements in chemistry.

Use of the analysis of covariance technique in the statistical treatment of the data led to certain conclusions that were not among the original stated objectives of the study. They are as follows:

1. ACT and MAT scores correlate highly with cumulative scores.

2. ACT scores are good predictors of future achievement in college.

Recommendations for Further Research

This study, as is true with most research, has provided some answers to the problem under consideration. The investigator of the present study is of the opinion that the stated findings or conclusions made from this research are important and significant to educators in science education and science teaching at all levels of the educative process, but especially at the college level.

In view of the findings in this study, some implications for research in chemistry achievement are apparent. They are as follows:

1. A replication of this study using one or more variables such as sex, number of courses in natural science during high school, or whether students have had previous experience in the use of programed materials.

2. An investigation of the mental and academic factors related to the successful completion of a general chemistry course.

3. An investigation using only programed materials versus the adopted textbook.

4. A replication of this study using a different adopted textbook or use the same textbook but use different programed materials.

5. An investigation of achievement in chemistry as measured by teacher constructed objective test of various lengths.

6. A replication of this study requiring the use of the supplementary programed materials as the lab-quiz hour operation rather than the review of chemical principles and calculations covered in the regular lecture periods.

Programed instruction may not be the panacea for methods of teaching courses at all levels but it certainly has proved, in many cases, to be as effective as the conventional method of instruction in teaching several skills and specified bodies of knowledge in the several disciplines. For the immediate future, it appears that programed instruction should be used to supplement regular courses rather than replace them entirely.

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APPENDIX A

CHEMISTRY 1015 SCHEDULE
FALL, 1968-69

WEEK OF	THEORY	LABORATORY (Sep 11-Nov 18, Lab expts begin on Wed)
Sep 11	Chapter 1, Introduction Chapter 2, Fundamental Principles	Metric Work Sheet (Hand-Out) Problems Page 293, Lab Manual
Sep 16	Chapter 3, Atoms & Subatomic Particles	Check-In Lockers - Exp. 2, Common Units
Sep 23	Chapter 4, Structure of Atoms	Exp. 3, Physical & Chemical Change
Sep 30	Chapter 5, Classification-Elements Periodic Table	Exp. 4, Conservation of Mass (½)
Oct 7	Chapter 6, Formulas & Equations Chapter 10, Valence	Exp. 4, concluded
	M.A.T. #1, FRIDAY, OCTOBER 11	
Oct 14	Chapter 11, Chemical Bonds	Drill: Symbols, Formulas, & Equations
Oct 21	Chapter 12, Classification of Compounds & Nomenclature	Special Experiment (Visible Changes)
	*<u>FIRST HOUR EXAMINATION - THURSDAY - OCTOBER 24 - 5:30 P.M.</u>	
Oct 28	Chapter 15, Stoichiometry	Exp. 9, Law of Definite Proportions
Nov 4	Chapter 7, Oxygen	Exp. 10, Displacement Reactions
	M.A.T. #2, FRIDAY, NOVEMBER 8	
Nov 11	Chapter 8, Hydrogen	Exp. 8, Oxygen
Nov 18	Chapter 9, Gaseous States of Matter	Exp. 11, Hydrogen
	M.A.T. #3, FRIDAY, NOVEMBER 22	
Nov 25	Chapter 13, Water & Liquid State	THANKSGIVING VACATION
Dec 2	Chapter 14, The Solid State	Exp. 13, Water and Exp. 14, Hydrates

CHEMISTRY 1015 SCHEDULE
FALL, 1968-69
(continued)

WEEK OF	THEORY	LABORATORY
	*SECOND HOUR EXAMINATION - THURSDAY - DECEMBER 5 - 5:30 P.M.	
Dec 9	Chapter 17, The Halogens	Exp. 12, Equivalent Weights & Valence
Dec 16	Chapter 22, Nitrogen & the Atmosphere	Exp. 31, Chlorine and Exp. 32, Hydrogen Chloride
Dec 23	CHRISTMAS VACATION	CHRISTMAS VACATION
Jan 6	Chapter 23, Nitrogen Compounds	CHECK-IN LOCKERS
Jan 13	FINAL EXAMINATION WEEK	
	*FINAL EXAMINATION - TUESDAY - JANUARY 14 - 7:30-9:20 A.M.	

*All examinations are given in P.S. 141, E.S. 317 and E.N. 108. Your laboratory instructor will assign your room and seat. You will have the same room and seat assignments for each examination.

CHEMISTRY 1015 STUDY GUIDE
CHAPTERS 1 and 2

Read Chapter 1 for information. Remember two things - what were the alchemists trying to do? And page 5, not in detail, but pick out all the familiar things you use every day.

Chapter 2 - The universe consists of two things. What are they?

Matter...elements...compounds...mixtures...which of these are called pure substances? Why?

Properties...two kinds of matter...physical and chemical...pick a few of each...try to get a working definition of each.

Elements...pure substances...two kinds...metals and non-metals...name a few you know...NO CHEMICAL CHANGE over breaks an element into smaller pieces...but a physical change inside an atom...an atomic bomb...can and does destroy certain elements...Matter into ENERGY.

The smallest particle of an element...an atom...each element represented by a SYMBOL...some elements exist as atoms...others have two or more atoms stuck together...these are called molecules...so an element may exist as either atoms or molecules...molecule...a particle with two or more atoms acting as a single unit.

Elements...page 14...learn the four most abundant elements in the Earth's crust.

Compounds...ALWAYS CONTAIN MORE THAN ONE ELEMENT...exist as molecules or?...are pure substances...so have a definite set of properties... name one for sugar...NOW go to page 12 and relate compounds and elements.

Things to remember...atoms are represented by a symbol...molecules by a formula.which will a compound always have? Spend a little time on page 15...types of compounds...do not memorize YET.

Study the definition of Law of Conservation of Mass...what kind of change is mentioned? Likewise (page 16) Law of Conservation of Mass.. what kind of change is mentioned? Forget Multiple proportions...read but do not attempt to memorize combining weights and equivalent weights.

Symbols...page 20...start learning them now.

Formulas...at least two atmos stuck together...O_2...(that little number is written below is mean)...learn it now...a subscript...this is a symbol or a formula...that two means that two atoms are acting as a unit.

The Metric System will be discussed in lab and quiz hours...not in lecture...try some of the problems at the end of the chapter.

CHEMISTRY 1015 STUDY GUIDE
CHAPTERS 3 and 4

Read the chapters first and then go back and study the paragraphs.

CHAPTER 3. Dalton's atomic theory based on laws of chemical change. Modern revision of Dalton's theory.

Equivalent Weights: Weight of element that will unite with or displace 1.008 grams hydrogen or 8 grams of oxygen.

Gram Atom is atomic weight expressed in grams. Atoms made up of sub-atomic particles, electrons, protons, and neutrons. Discovery and characteristics of each. Define as particles.

CHAPTER 4. Atoms are largely empty space. Hydrogen the simplest atom, only one with no neutrons. Two parts of an atom; nucleus and electrons. Electrons in orbits are called energy levels; K, L, M, N, or 1, 2, 3, 4. $2n^2$ when n is the member of the orbit.

Understand relation of mass number, atomic number, and electrons. What three things do you learn from $_{19}K^{39}$? Valence electrons are in general those in outermost orbit and determine effect of an outer orbit which contains 8 electrons.

How valence of metals differ from valence of nonmetals as to charge.

Quantum numbers, what are they?

Meaning of subshell energy levels s,p,d,f. Number of orbits and number of electrons possible in each.

What element is this? (X) 2 2 6 2 3 Label the subshells.

What are paired electrons? Will electrons pair up or will they occupy orbitals singly until all the orbitals in that energy level are filled?

Draw structure of $_{20}$CA - $_{21}$Sc, $_{29}$Cu, and $_{30}$Zn, which show order of filling electrons. Figures 4-13, p. 44.

What causes variable valence? What is the structural similarity of Na and K, F, Cl, and Ne and A?

Atoms of most elements have different masses. Why? What are they called? Atoms combine in two ways. Explain.

Is it correct to speak of a molecule of salt? How many electrons are shared by each atom when Ca^{++} combines with $2Cl^-$?

Show the dot system for the formula of $AlCl_3$ and CF_4.

Note the formula H-O-H. What does each line represent?

When metals combine with nonmetals what kind of valence? When carbon combines with chlorine, what kind of valence and what relationship?

Understand the meaning of molecular weights, formula weights, and moles.

Work Parts A and B of problems 13 and 14.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 5

Elements are arranged according to increasing atomic numbers. Elements occur in horizontal rows called Periods ending with an inert gas. Vertical columns are called Families or Groups, numbered IA - VIIIA and IB - VIIIB. Each Family has similar properties. Horizontal rows contain 2-8-8-18-18-18-32-17 = 103 elements.

Some Families or Groups have special names: alkali, IA; alkaline earth, IIA; inert gases, VIIIA; halogens, VIIA. In all A Groups, the positive oxidation number is the same as the group number.

Group IVA, VA, VIA, and VIIA are, for the most part, nonmetals and can be negative or positive. Valence is the group number subtracted from 8 for negative valence, VIIA 8 - 7 = -1 for F^-, Cl^-, Br^-, and I^-. The B groups or families are all metals and have varying valence. Remember, they are transition elements filling in electrons in D and F orbitals. These groups will be discussed by using individual elements as examples. Going down the groups, all elements in the group have the same number of electrons in the valence shell, but each adds an inner ring of electrons. Properties and valences are much alike.

Activity of metals tend to increase as we go down the group, but tend to increase for nonmetals as we go up in VIA and VIIA. KNOW THE PERIODIC LAW.

Historical development. Dobereiner, Newlands, and Mendeleev: Point out A before K, Te before I, in Mendeleev order. Why? What is structure of inert gases? What are they inert?

Physical and chemical behavior of elements. Size of atom has great effect on properties. When shells are added the size increases, thus, Li is smallest and Fr is largest in IA. In a given period the atoms decrease in size. Find out why.

The ion of an atom after loss of electrons is smaller than the atom. What happens to size of atom when electrons are added to form negative ions?

Ionization potential definition. Why low for IA metals? Why high for VIIA nonmetals?

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 6

1. Learn meaning of weight indicated in a formula...molecular weight.. gram molecular weight when expression in grams...know meaning of terms subscript and coefficients...as $3HNO_3$ or $3H_2SO_4$.
2. A chemical equation used to represent a chemical change as
   $2H_2 + O_2 \quad 2H_2O$
   Which gives what information?
3. The term radical is another word for complex ion such as OH^- or NH_4^+.
4. Types of reactions:
   a. element plus element...combination...working rules
      (1) any metal will react with nonmetals
      (2) nonmetals react with nonmetals
      (3) in most cases metals DO NOT react with metals
   b. decomposition...any compound can be broken down to simpler substances...
      $2HgO + heat \rightarrow 2Hg + O_2$ (works for a few compounds)
      $2\ H_2O$ + electrical current $\rightarrow 2H_2 + O_2$
      ONLY ONE COMPOUND INVOLVED
   c. ionic exchange...often called double decomposition...TWO compounds involved...RULES:
      (1) Something must be lost, as a gas, as a precipitate, as a covalent molecule.
      (2) If nothing is gaseous, insoluble or covalent, the ions set up a kind of teeter-totter...equilibrium...and no visible results are seen.
   d. Replacement or substitution...a compound + an element
      $2HCl + Mg \rightarrow H_2 + MgCl_2$
      (1) Element must be MORE ACTIVE than one of the elements in the compound.
5. Some things to learn:
   a. An arrow pointing up means the substance escapes as a gas.
   b. An arrow pointing down means that the substance is insoluble in the solvent present...usually water.
   c. TWO WAYS OF WRITING THIS EQUATION:
      $AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$ (water is the solvent) OR
      $Ag^+ + NO_3^- + Na^+ + Cl^- \rightarrow AgCl + Na^+ + NO_3^-$ (IONIC)
      (WE WILL SAVE THE THIRD WAY FOR LATER)
   WHAT IONS DISAPPEARED IN THE REACTION?
6. Calculations from formulas:
   a. finding the molecular weight...formula weight..or for one MOLE READ CAREFULLY bottom page 78.
   b. per cent composition, first need formula weight or molecular weight, then see bottom of page 78, % = part/whole X 100.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 10

We use valence and a new term oxidation number to express combining power of elements. Outer electrons determine valence for elements in A Groups.

Elements tend to complete outer energy level to 8e's. If they transfer, they are called electrovalence. Metals tend to give up electrons, nonmetals to gain them. No valence for free element - I, II, III A constant valence. 4-5-6-7 A Groups vary in valence - so do transition elements. In B Groups varying valence is due to loss of electrons from d suborbitals.

The sum of valences in most compounds is equal to 0. Valence is determined by experiment (weight of element that will combine with 1 gram of H or 8 grams of O or their equivalents).

Sharing e's between atoms - covalence - CH_4, CCl_4, HCl, H_2O, Cl_2. Covalence is number of electron pairs shared. Atoms in covalent compounds are tightly held - from molecules. Purely ionic compounds form crystals of ions - not molecules. Covalent compounds that react with water form ions in solution: $HCl + H_2O \rightarrow H_3^+O + Cl^-$.

In covalent compounds the valence may be expressed as a number without charge. When a charge is assigned it is called oxidation number or oxidation state. Remember free element = 0, H in compounds +1, O in compounds -2. Ions are + or - in charge. Assign oxidation number to $Ca(\underline{Mn}O_4)_2$, $(NH_4)_2\underline{Cr_2}O_7$, $H_3\underline{As}O_4$.

Oxidation is a reaction where the oxidation number increases.

Reduction is a reaction where the oxidation number decreases.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 11

1. Chemical bonds
   a. covalent...formed between two unpaired electrons...equal sharing
   b. coordinate...formed between an atom, ion, or molecule. SHORT TWO ELECTRONS and another particle which has a pair of unshared electrons...REPEAT - A PAIR OF UNSHARED ELECTRONS. (This bond usually turns into a regular covalent bond by RESONANCE of all the electrons in the adjacent atoms)
   c. Ionic...bonds of ATTRACTION between OPPOSITELY CHARGED ions which were formed by an exchange of electrons...one gave up the electrons...the other gained them.

2. The covalent bond...strong...directional...DOES NOT shift about or change partners easily.

3. The coordinate bond...not as strong as a regular covalent bond... otherwise the same.

4. Ionic bond...fairly strong...completely polygamous...NOT DIRECTION-AL...A sodium ion could care less with what negative ion it holds hands with, so long as the thing has a negative charge.

5. Polarity of a bond...a magnet has poles...negative and positive... ionic bonds are 100% polar...COMPLETELY SEPARATED CHARGES...cova-lent bonds vary from non-polar to highly polar...SHAPE of molecule plays important part in polarity...REMEMBER that covalent bonds are DIRECTIONAL...pages 137, 138, 139.

6. Shapes of molecules...RULE...electron pairs get as far away from each other as possible...draw electron dot picture of each of the following and decide what will be their shapes, BeH_2, BH_3, CH_4, H_2O.

7. Polarity...Cl-Cl is non-polar...symmetrical charges on nucleus... linear...H-Cl...polar...unsymmetrical...nuclear charge on H is 1+, on Cl is 17+...so electrons of bond are SHIFTED TOWARD Cl...leaving a partial + charge on the H and partial - charge on Cl. BeH_2...or H-Be-H...the two pairs of electrons are as FAR APART as possible... what is the angle?...molecule is symmetrical...non-polar...try this with CH_4...with water.

8. Hydrogen bonding...this is the stickum which makes water so valu-able...and holds your muscles together...or the wood in the chair you use (actually liquid water has a formula something like $(H_2O)_{2}$, 4,6,8, etc., due to hydrogen sitting down on the extra pair of electrons on the oxygen of another water molecule).

9. Things to read, BUT NOT to memorize...Table 11-1 and Table 11-2... these may help in explaining some energy changes in chemical reactions later.

   Van der Waal's forces...interaction between molecules NOT due to bonding...WEAK, but important to study of gases and liquids.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 12

1. Acids...any compound which can furnish protons...two types most important...oxygen acids...H_2SO_4 or HNO_3...and nonoxygen acids... HCl or H_2S.

   LEARN meaning of and formula for hydronium ion H_3O^+.
   LEARN general properties of acids...especially their chemical ones

2. Bases...general definition...any substance which can ACCEPT a proton...learn how this applied to metallic hydroxides...formation of water from...NOTE what ions are formed when a metallic hydroxide is placed in water...LEARN general properties, especially chemical properties and solubility.

3. Salts...are ionic...hence solids...associate salts with reaction of an acid with a base...neutralization.

4. Write the equation for the reaction between NaOH and HCl in water. First as molecules...THEN as IONS...what PULLS the reaction to the left?

5. Study carefully pages 147-148...paying close attention to classes of reactions and the compounds written as ions.

6. Naming acids...two kinds of acids are?????
   a. Nonoxygen acids...HYDRO__________ic HCl...HYDRO chlor ic acid
   b. Oxygen acids _______ic, or _______ous...H_2SO_4...sulfur ic acid

      H_2SO_3...sulfur ous acid...ic goes with higher oxidation number and ous with lower oxidation number of acid former...here S
      NOTE Cl has four oxidation numbers...7+, 5+, 3+, and 1+...tie in with PER...IC...OUS...HYPO_______OUS.

7. Bases...HYDROXIDES...$Ba(OH)_2$ Barium HYDROXIDE.

8. Oxides...TWO TYPES...metallic nonmetallic as BaO and CO_2.
   Names end in IDE...barium oxide or carbon dioxide...note DI...?
   a. General rule...metallic oxides...NO MENTION OF NUMBER OF OXYGEN ATOMS as Al_2O_3...aluminum oxide...NONMETALLIC OXIDES... usually at least two for each nonmetal...so number of oxygens given...CO...carbon monoxide.
   b. Metallic oxides of transition metals...OUS and IC...LOWER and HIGHER oxidation numbers as FeO...ferrOUS oxide or Fe_2O_3... ferrIC oxide...also iron(II) oxide and iron(III) oxide.
   c. Metallic oxides also known as BASIC ANHYDRIDES...bases WITHOUT WATER...NOTE page 152.
   d. Nonmetallic oxides also known as ACIDIC ANHYDRIDES...acids WITHOUT WATER...CaO + CO_2...CaCO + $CO_2 \rightarrow CaCO_3$ or

$$Ca(OH)_2 + H_2CO_3 \rightarrow CaCO_3 + HOH$$

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 12 (continued)

9. Learn to recognize...ACID salts as $NaHSO_4$ or $NaHCO_3$...BASIC salts as CaOHCl...or some compounds which cannot make up their minds and can be either acids or bases...AMPHOTERIC.

10. Salts...TWO ELEMENTS...end in IDE...contain OXYGEN...ATE or ITE see oxygen acids...IC acid gives ATE salt...OUS acid gives ITE salt...H_2SO_4...$CaSO_4$ calcium sulfate or H_2SO_3...$CaSO_3$ calcium sulfite.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 15

1. Yield problems:
   a. Complete and balance the equation...as how many grams of water formed from 16 g of hydrogen?

   $$2H_2 + O_2 \rightarrow 2H_2O$$

   b. Put on top of equation what you have as

   $$\overset{16\ g}{2H_2} + O_2 \rightarrow \overset{X}{2H_2O}$$ (note: that oxygen is neglected after balance).

   c. Put indicated weights under equation

   $$\underset{4\ g}{\overset{16\ g}{2H_2}} + O_2 \rightarrow \underset{36\ g}{\overset{X}{2H_2O}} \qquad 2H_2 \quad 4\ g \qquad 2H_2O = 36\ g$$

   d. Then set like over like equal to each other as

   $$\frac{16\ g}{4\ g} = \frac{X}{36\ g}$$ and solve where X is the amount of water

   e. OR BY MOLE method...note that 2 MOLES of H_2 yield 2 MOLES of water...SO ONE mole of H_2 yields one mole of water...NOW FIND FIND MOLES of H_2...$\frac{16\ g}{2\ g}$ or 8 moles... 8 x 18 g or 144 g.

2. Gases...Statements to learn:
   a. Standard conditions for gases 0 C and 1 atmosphere pressure (760 mm pressure...or this height of mercury supported by the gas).

   b. A gram molecular weight of ANY GAS occupies 22.4 liters at standard conditions...(STP)...one MOLE of any gas occupies 22.4 liters at STP.

   c. The NUMBER OF MOLECULES in 22.4 liters of ANY gas at STP is 6.02×10^{23} or ONE MOLE OF MOLECULE...Avagadro's Number.

3. Weight volume calculations...What volume of hydrogen at STP will be formed by 23 g of sodium when reacted with water?
   a. Complete and balance: $2Na + 2HOH \rightarrow H_2 + 2NaOH$

   b. Put weight and volume above equations

   $$\overset{23\ g}{2Na} + 2HOH \rightarrow \overset{22.4\ liters}{H_2} + 2NaOH$$ ONE MOLE of H_2 occupies???

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 15 (continued)

3. c. Put results under the equation

$$\begin{array}{lcccc} 23\text{ g} & & & 22.4\text{ liters} & \\ 2Na & + & 2HOH \rightarrow & H_2 & + 2NaOH \\ 26\text{ g} & & & X\text{ liters} & \end{array}$$

d. Put like over like equal and solve

$$\frac{23\text{ g}}{46\text{ g}} = \frac{22.4\text{ liters}}{X\text{ liters}}$$

e. OR MOLE METHOD

ONE MOLE of Na yields ONE-HALF MOLE of hydrogen, so one-half mole of H_2 at STP occupies $\frac{22.4\text{ liters}}{2}$

4. Volume...volume calculations...APPLY to

$H_2 + Cl_2 \rightarrow 2HCl$ (all gases) ONE MOLE of H_2 yields TWO MOLES of HCl...same steps ONLY USE VOLUMES.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 7

1. For any new substance you should learn:
   a. Occurrence...where and how...as oxygen...free in air...combined in ?
   b. Preparation...Laboratory...Commercial
      (1) Heating of oxygen compounds...HgO; PbO_2; $KClO_3$...Laboratory preps...commercial...liquefaction of air...and distillation of air
   c. Properties...physical and chemical
      (1) Gas...slightly soluble in water...colorless...tasteless
      (2) Chemical...free oxygen is INACTIVE at lower temperatures, at higher temperatures...excellent OXIDIZING AGENT... rusting of iron...equation...other elements...reactions with compounds...learn difference between rusting and COMBUSTION...reacts with BOTH metals and nonmetals to form OXIDES...write typical reactions.
   d. Uses...in your body...in a furnace...in an automobile...in a torch...its reactions are EXOTHERMIC...production of heat energy.

2. Oxides...metallic and nonmetallic...as CaO and CO_2
   a. Metallic oxides...are BASIC ANHYDRIDES...$CaO + HOH \rightarrow Ca(OH)_2$
   b. Nonmetallic oxides...are ACID ANHYDRIDES...$CO_2 + HOH \rightarrow H_2CO_3$
   c. Metallic oxide + nonmetallic oxide → salt as
      $CaO + CO_2 \rightarrow CaCO_3$ compare with
      $Ca(OH)_2 + H_2CO_3 \rightarrow CaCO_3 + 2HOH$

3. Reactions to be studied:

   $HgO + heat \rightarrow$

   H_2O + el current →

   $S + O_2 \rightarrow$

   $Fe + O_2 \rightarrow$

   $CH_4 + O_2 \rightarrow$

   $BaO + HOH \rightarrow$

   $BaO + SO_2 \rightarrow$

   $KClO_3 + MnO_2 + heat \rightarrow$

   $PbO_2 + heat \rightarrow$

   $SO_2 + O_2 \rightarrow$ (Note: reactions below this point should be repeated with other compounds)

   $P + O_2 \rightarrow$

   $C_8H_{18} + O_2 \rightarrow$

   $SO_2 + HOH \rightarrow$

   $Ba + SO_3 \rightarrow$

4. NEW IDEAS
   a. Catalyst...$KClO_3 + heat \rightarrow KCl + O_2$ ...extremely slow

      $KClO_3 + MnO_2 + heat \rightarrow KCl + O_2 + MnO_2$ ... very fast

   WHAT DOES THE MnO_2 DO?

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 7 (continued)

4\. b. Oxidizing agent...any substance which removes electrons from another substance...put oxidation numbers on each of the following:

$C + O_2 \longrightarrow CO_2$ which element gained electrons by removing from another...oxidizing agent

c. Combustion...oxidation reaction going FAST ENOUGH to give off BOTH HEAT AND LIGHT...again compare to rusting of iron

d. Kindling temperature...temperature at which slow oxidation becomes?...relate to spontaneous combustion

e. OZONE...O_3...different form of oxygen...allotrope...deadly... cause of SMOG in many cities...definite ODOR...EXTREMELY active chemically.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 8

1. Hydrogen...occurrence...the fuel of the universe...atomic fusion to produce energy in the sun and stars...on earth...rare as free element...combined...water...acids...bases...all living matter contains fats, carbohydrates and protein...compounds of hydrogen... petroleum is a mixture of hydrocarbons

2. Preparation...laboratory by action of a metal on an acid as
   $Zn + 2HCl \rightarrow H_2 + ZnCl_2$

   Commercial...$C + H_2O(steam) \rightarrow CO + H_2$ or electrolysis of water or cracking of hydrocarbons

3. Properties...physical...exists as a gas, etc...chemical...decide what happened to hydrogen in the equation $H_2 + O_2 \rightarrow H_2O$;

   The hydrogen LOST ELECTRONS...definition of a REDUCING AGENT...also hydrogen reacts DIRECTLY with most nonmetals and many active metals in the family A series...examples:
   $H_2 + Cl_2 \rightarrow HCl$ or $Na + H_2 \rightarrow NaH$....name the two products.

4. Hydrogen used as the YARDSTICK for the REDUCING POWER OF METALS... called the activity series...study Figure 8 on page 98...note position of hydrogen...statement...ANY METAL ABOVE HYDROGEN WILL REPLACE HYDROGEN FROM ACIDS...THOSE BELOW IT WILL NOT REPLACE HYDROGEN FROM ACIDS...also an ELEMENT will REPLACE any element BELOW it from the compounds of the lower element...as
   $Cu + HCl \rightarrow$ NO GO, but $Fe + HCl \rightarrow H_2 + FeCl_2$

   $Na + CuCl_2 \rightarrow Cu + NaCl$, but $Cu + PbCl_2 \rightarrow$ NO GO

5. Uses...ONCE used in balloons...TOO DANGEROUS...WHY? chief uses... making fertilizer...AMMONIA...NH_3...motor fuels as high test gasoline...oleomargarine or Crisco...synthetic SOLID cooking fats and spreads...latter process called Hydrogenation...or hardening... actually a type of reduction using the reducing power of hydrogen.

6. Reactions for which you are responsible:

   Metals + acids as
   $Cu + H_2SO_4 \rightarrow$ $\qquad$ $Fe + H_2SO_4 \rightarrow$

   Metals + water as
   $Na + HOH \rightarrow$ $\qquad$ $Ag + HOH \rightarrow$

   Metals + salts, oxides, etc., as
   $Cu + FeCl_2 \rightarrow$ $\qquad$ $Fe + CuO \rightarrow$

   $Na + FeCl_2 \rightarrow$ $\qquad$ $Zn + KOH \rightarrow$

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 9

1. Study this expression: solid + heat → liquid + heat → gas in relation to the KINETIC ENERGY of the particles...WHICH state has the most KINETIC ENERGY?

   The particles (molecules) of a gas are COMPLETELY INDEPENDENT of each other so they can
   (a) expand without limit if not in a container...they will completely fill any container.
   (b) they continually HIT the walls of a container and EXERT A PRESSURE
   (c) the pressure depends on both the number of molecules and on the TEMPERATURE
   (d) TO DESCRIBE A GAS we must specify THREE THINGS...VOLUME... TEMPERATURE... and PRESSURE...the temperature will be Kelvin or absolute...

2. Volume and pressure with a CONSTANT temperature...TWO ways to change the pressure...WHAT are they? CHANGE temperature or pressure...BUT WITH A CONSTANT TEMPERATURE...THE ONLY WAY is to change the volume...
   (a) One liter of a gas is changed to 500 ml. What happens to the pressure? Pressure is caused by molecules hitting the walls of the container...the more hits, the higher the pressure... in 500 ml there are twice as many hits as in one liter, SO?

3. Pressure and temperature at CONSTANT volume...one liter of a gas at 20 C is heated to 100 C...VOLUME cannot change...what happens to the speed of the molecules when heated? They go faster, hit harder and more often...SO how does PRESSURE VARY WITH TEMPERATURE?

4. Volume and temperature at CONSTANT pressure...basis for the Kelvin or absolute temperature scale...COOL A GAS and it contracts at CONSTANT pressure...at 0 C any gas IF COOLED ONE DEGREE LOSES 1/273 of its VOLUME...SO WHAT TEMPERATURE IN CENTIGRADE will it have NO VOLUME?...at -273 C. This is ZERO degrees Kelvin or absolute...ALL KINETIC ENERGY IS GONE...THEREFORE NO MOTION OF THE MOLECULE...the temperature of FREE SPACE.

   Temperature Kelvin = Centigrade + 273...a -10 C = 263 K...
   Kelvin has NO BELOW ZERO...starts at ZERO

5. Each gas in a mixture of two or more gases acts as though it were alone...exerts its own pressure...THEREFORE the total pressure is equal to the sum of the PARTIAL PRESSURES in a mixture of gases... air for instance.

6. The Kinetic Theory of Gases
   (a) Gases consist of individual molecules
   (b) The molecules occupy VERY LITTLE of the total space...lots of room

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 9 (continued)

6. (c) Molecules in constant motion...move in straight lines UNTIL they hit another one or the walls of the container...YOU are holding up SEVERAL THOUSAND POUNDS OF PRESSURE BECAUSE AIR MOLECULES ARE HITTING YOUR BODY
   (d) Molecules are perfect bouncers...perfectly elastic...lose NO energy in collisions with objects of the same temperature
   (e) Velocity depends on temperature...the hotter the faster
   (f) Average kinetic energy of particles at same temperature is identical...regardless of mass...as K.E. = mv^2...the bigger they are...the slower

7. Combining volumes...22.4 liters...standard conditions, etc.

CHEMISTRY 1015 STUDY GUIDE
CHAPTERS 13-14

WATER AND THE LIQUID STATE

1. Liquid state compared to gaseous...molecules are closer together... have less kinetic energy...are moving more slowly...are NOT independent of each other...attractice forces hold, but not tightly enough to prevent evaporation.

2. All liquids have a VAPOR PRESSURE or TENSION...depends on temperature...in a closed system...vapor reaches equilibrium with molecules GOING BACK into a liquid...in open system evaporation CONTINUES...molecules escape. BOILING POINT...energy is required. goes into PULLING MOLECULES APART...definition...TEMPERATURE at which the VAPOR PRESSURE of the liquid is EQUAL to the PRESSURE ON the liquid from outside...boiling point for a compound VARIES DIRECTLY WITH THE EXTERNAL PRESSURE.

3. Determine the meaning of terms...surface tension...viscosity... volatile liquids.

4. WATER...an unusual liquid...hydrogen bonding and polarity makes it a high boiling liquid...polarity and hydrogen bonding cause it to be the BEST SOLVENT for any compound which is IONIC, or contains like groups as C=OH, or has an unshared pair of electrons as NH_3.

5. Heavy water...the kind most students are in is HOT...explain from standpoint of isotopes of hydrogen.

6. Hydrates...these ARE COMPOUNDS in which water is bound to one or more IONS in an ionic compound as $CuSO_4 \cdot 5H_2O$...FOUR of the water molecules are attached to the Cu ion...one to the sulfate ion... definite composition...a very common hydrate in Oklahoma... gypsum...has the formula $CaSO_4 \cdot 2H_2O$...MANY compounds when exposed to air will either GAIN OR LOSE water...deliquescence or efflorescence...forming a hydrate or decomposing one...

7. A peculiar compound...H_2O_2...ONE OXYGEN too many...peroxides... hydrogen peroxide...bleaching agent for brunettes, etc...Germans used pure H_2O_2 in rockets during attack on Britain.

8. SOLID state...ORDERLY CLOSE PACKED arrangement of molecules or ions in crystals...movement very small...attractive forces much greater than kinetic energy...TWO MAJOR TYPES of crystals...IONIC and covalent...the MELTING POINT...TEMPERATURE at which the SOLID state and the LIQUID STATE can exist in EQUILIBRIUM...METALS have a special kind of bonding...metalling bonding...

9. CHANGE OF STATE...solid $\rightarrow$ liquid $\rightarrow$ gas...MUST ADD ENERGY...reverse gas $\rightarrow$ liquid $\rightarrow$ solid...energy is released...on this base figure out HOW the temperature of the earth REMAINS in a narrow range DUE to so much water...solid, liquid, and gaseous.

CHEMISTRY 1015 STUDY GUIDE
CHAPTERS 13-14 (continued)

10. What is the weight of water in your body? Will 10 ml of water at 2 C weigh more or less than 10 ml of water at 10 C? Explain.

11. Be able to define these terms...specific heat, heat of fusion, heat of solidification, heat of vaporization, and heat of condensation...calculate the number of kilocalories necessary to change 10 Kg of water at 100 C to steam.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 17

HALOGENS

GENERAL FAMILY CHARACTERISTICS: Atomic structure 7 electrons can thus gain 1 electron and become -1. With exception of F, halogens are able to share electrons, give oxidation number +1, +5, and +7. Note change in properties as the atomic weight increases. None are free in nature. Cl most important.

CHLORINE...(discovered by Scheele in 1774 by MnO_2 + HCl...thought a compound...Davey in 1910 found it to be an element). Occurrence... NaCl principal ore also occurs in sea water as $MgCl_2$, KCl, and $CaCl_2$. In the body, NaCl in blood and HCl in stomach.

Preparation...electrolysis of water solution of NaCl...Cl^- ions are discharged at anode. The Na^+ reacts with the water forming NaOH and H^+...H_2 discharged at the cathode...($2NaCl + 2H_2O \rightarrow 2NaOH + H_2$). The Cl^- ion loses an electron and is oxidized. In the lab MnO_2 + HCl. Mn^{++++} IS THE OXIDIZING AGENT. Other oxidizing agents to produce Cl_2 from HCl are: $KMnO_4$, $K_2Cr_2O_7$, HNO_3, $KClO_3$, and PbO_2.

Physical Properties...green, yellow gas, irritating to throat and lungs. First gas used in World War I. Sol. 2.25 volumes in 1 volume H_2O at 20 C. Can be condensed to liquid at -34.5 C and 1 at. pressure.

Chemical properties...unites with metals to form chlorides. Unites with nonmetals P, S, H, to form covalent compounds.

Reactions: $CH_4 + 2Cl_2 \rightarrow C + 4HCl$

$Cl_2 + H_2O \rightarrow HCl + HClO$

with bases: $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$

Uses...bleach in water...on cotton...not on silk and wool. Also bleaches wood pulp used to make paper and rayon. Pathogenic organisms are destroyed by Cl_2. Two parts to 1×10^6 parts in water. (Used to make mustard gas...phosgene and chloropierin).

BROMINE...(discovered in 1826 by Balard from sea salt [Bromos stench]). Commercially from sea water.

Preparation...(1) displacement by Cl_2 $2NaBr + Cl_2 \rightarrow$

(2) electrolysis of $MgBr_2$ or oxidation of HBrO

(3) oxidation with $H_2SO_4 + MnO_2 + 2NaBr \rightarrow Na_2SO_4 + Br_2 + 2H_2O$

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 17 (continued)

Br_2 displaced from $MgBr_2$ by Cl_2 in sea water is collected by

$3Br_2 + 3Na_2CO_3 \rightarrow 5NaBr + NaBrO_3 + 3Cl_2$, then liberated by

$3H_2SO_4 + 5NaBrO_3 \rightarrow 3Na_2SO_4 + 3H_2O + 3Br_2$

Properties and Uses...is a liquid...produces burns on skin...soluble in water (limited), soluble in CS_2, CCl_4, and $(C_2H_5)_2O + C_2H_5OH$. Manufacture of dyes, drugs, and medicines...KBr in photography. Precipites AgBr...sensitive to light...$C_2H_4Br_2$ in ethyl gas. Combines with most metals and nonmetals like Cl_2.

IODINE...(discovered in 1812 by Courtois from sea weed). Kelp still principal source. $NaIO_3$ may be reduced with $NaHSO_3$.

Preparation...$2NaI + MnO_2 + 2H_2SO_4 \rightarrow Na_2SO_4 + 2MnSO_4 + I_2 + 2H_2O$
I_2 can be replaced from NaI by both Cl_2 and Br_2.

Properties...undergoes sublimation...soluble in water containing $2KI + 2I_2 \rightarrow KI \cdot I_2 + KI_3$...soluble in C_2H_5OH, CCl_4, $(C_2H_5)_2O$...starch turns blue in presence of I_2 (a test for I_2). Combines with most metals and nonmetals...forms iodides AgI...sensitive to light...also used in photography...solutions in alcohol are called (tinctures)... it is found in the thyroid gland.

FLUORINE...(discovered in 1886 by Moissau)...minerals are fluospar CaF_2, cryolite Na_3AlF_6, and apotite $[CaF_2 \cdot 3Ca_3(PO_4)_2]$.

Preparation and properties...extremely active...most negative of all elements...$2F_2 + 2H_2O \rightarrow 4HF + O_2$...prepared from HF in KHF_2 by electrolysis...will displace Cl, Br, and I from compounds...used to prepared Teflon $(C_2F_2)_x$ and Freon CCl_2F_2.

HALOGEN ACIDS...HF, HCl, HBr, HI...hydrohalogens form (ic) acids in water...can all be prepared by direct union of H_2 with the elements.

Lab: $NaCl + H_2SO_4 \rightarrow$
$CaF_2 + H_2SO_4 \rightarrow$
$NaBr + H_2SO_4 \rightarrow NaOHSO_4 + HBr$...but HBr is oxidized by con. H_2SO_4
$2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$

The same reaction for HI.
Pure acids can be prepared by NaBr or NaI reacting with H_3PO_4 (non-oxidizing acid) or by hydrolysis of PBr_3 or PI_3.

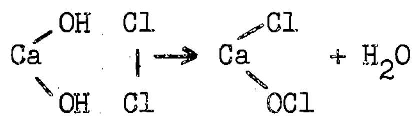
Physical Properties...colorless...are very soluble in water.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 17 (continued)

Chemical Properties...react with metals, bases, oxides of metals and carbonates...neutralize NH_3 forming NH_4Cl salt. HCl used in pickling both for sheet iron...used to hydrolyze sugars to make corn syrup.

HYDROGEN FLUORIDE...reacts with SiO_2 and $CaSiO_3$ in glass...dissolves... form SiF_4 (volatile) - HF is a weak acid while HCl, HBr, and HI are strong.

Oxygen compounds of the halogens...do not form oxides direct but Cl_2O + ClO_2, Cl_2O_5, and Cl_2O_7 can be made...are unstable...the acids of Cl are HCl, HClO, $HClO_2$, $HClO_3$, $HClO_4$...bleaching powder may be made by passing Cl_2 over $Ca(OH)_2$ to produce



a mixed salt

$KClO_3$ from $6KOH + 3\ Cl_2 \rightarrow KClO_3 + 5KCl + 3H_2O$

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 22

NITROGEN AND THE ATMOSPHERE

1. What is the function of free nitrogen in the atmosphere in regards to combustion where air is the oxidizing agent?

2. Combined nitrogen is found in proteins and practically all explosives as well as in all nitrogen containing fertilizers.

3. Two inorganic compounds found in nature containing nitrogen are _______________ and _______________.

4. Oxygen may be removed from air leaving nitrogen by (1) liquification of air and then distillation, (2) by use of white phosphorus.

5. (a) N_2 may be obtained from $NaNO_2$ and NH_3. How? _______________
   (b) When N_2 is converted into a nitrogen compound, the process is called _______________.

6. Describe natural and artificial fixation of nitrogen.

7. Starting with N_2 trace the cycle of changes nitrogen undergoes in nature.

8. Name six substances that are present in a sample of air. Identify as elements or compounds.

9. List three principal methods by which CO_2 gets into the air. Why is the CO_2 content of the air about constant?

10. What is the process of combination of CO_2 and H_2O in plant tissue called?

11. What is the meaning of the term humidity in the atmosphere? How is it determined? What causes dew or fog to form?

12. Write out the dot formula for $_2He$, $_{10}Ne$, $_{18}Ar$, $_{36}Kr$. What structure do the last three have in common?

13. Where was He first discovered? Why is it mixed with oxygen for use under high pressure?

14. What is the per cent of Ar in air? What is commercial use of Ar?

15. Name five compounds that contribute to pollution of air.

CHEMISTRY 1015 STUDY GUIDE
CHAPTER 23
NITROGEN COMPOUNDS

1. Nitrogen in most compounds is covalent...common oxidation numbers are -3, +3, +4, +5.

2. NH_3 produced in nature by decay of porteins...also prepared by distillation of soft coal, horns, and hoofs. Prepared in lab from salts and strong base...give equations...Why is NH_3 not collected by water displacement?...metal nitrides reacting with water.

3. Commercial complex compounds of nitrogen in coal are converted to NH_3 when heated in absence of air...how is ammonium sulfate made? What is its use? Haber process...union of elements...what is the effect of increased pressure on the equilibrium yield of ammonia? (Apply LeChatelier's principle)...what are the raw materials used in the cyanamid process? Write the equations.

4. What element is oxidized and what element reduces when NH_3 burns in O_2 in the presence of a catalyst?

5. Nitric acid and nitrates: (1) prepared in lab from $NaNO_3$ and H_2SO_4. Why could HCl not be used? (2) write the reactions for the Oswaldt process...what happens to the NO produced in the third equation, page 308? (3) HNO_3 is an oxidizing agent. Mole for mole, what is the best oxidizing agent for Cu, dilute HNO_3 or concentrated HNO_3? (4) nonmetals S, P, and C can be oxidized with hot concentrated HNO_3...what are the products? How are glycerine and toluene nitrated? Name the products...how many liters of gas could be formed when 4 moles of nitroglycerine decomposes? Make the assumption that the temperature is 273 C and there is no change in pressure. Give the formula for these oxides of nitrogen... nitrous oxide, nitric oxide, nitrogen dioxide, nitrogen trioxide, and nitrogen pentoxide.

APPENDIX B

CHEMISTRY 1015
Lab Sections 1 and 2
Supplementary Study Guide from Programed Supplements

LEGEND: Chemical Symbols = volume A
Chemical Formulas and Names = volume B
Molecular Weight Calculations = volume C
Balancing Chemical Equations = volume D
Weight and Volume Relationships = volume E

TEXT	PROGRAMED TEXT
Chapter 3	p. 10 items 42-72 (C) p. 33 item 3 and p. 40 item 60 (C)
Chapter 4	p. 5 items 12-29 (B) pp. 38-41 (C); p. 16 items 1-2 (B) p. 9 items 34-41 (C) p. 34 items 1-17 (B) p. 42 items 63-73 (B)
Chapter 5	p. 15 item 1 (D) p. 11 item 60 (B) pp. 2-30 (A)
Chapter 6	pp. 2-14 (D); p. 3 items 1-5 (B) p. 9 item 48 (B); p. 11 item 63 (B) p. 12 item 66 (B); p. 16 item 3 (B) p. 15 item 1-16 (D) p. 21 item 27 (D); and p. 14 items 67-83; p. 19 items 4-8; p. 20 items 9-12; p. 21 items 18-22; p. 24 item 41 (E)
Chapter 10	pp. 34-44 (D); pp. 34-46 (B)
Chapter 11	p. 3 items 1-5 (B); p. 3 item 6 (D) p. 11 item 60 (B)
Chapter 12	pp. 48-59 (B); pp. 34-47 (D) p. 16 items 4-8 (D); pp. 5-14 (D) p. 23 items 32-33 (D) pp. 6-15 (B)
Chapter 15	pp. 3-14 (E); pp. 23-32 (E) pp. 15-22 (E)
Chapter 7	pp. 5-7 (D); p. 17 items 27-30 (A) pp. 4-7 items 14-26 (D) p. 4 item 8 (E); p. 11 items 45-51 (E); p. 33 items 1-4 (E); p. 21 items 16-17 and 22 (E)

CHEMISTRY 1015
Lab Sections 1 and 2
Supplementary Study Guide from Programed Supplements
(continued)

TEXT	PROGRAMED TEXT
Chapter 8	p. 4 items 11 and 14 (A); p. 14 item 1 (A); p. 13 items 58-60 (B) p. 21 items 18-21 (B) p. 18 item 21; p. 20 item 28 p. 22 item 36; p. 30 items 43-44 (E)
Chapter 9	pp. 15-36 (E)
Chapter 13	p. 13 items 57-61 (B) p. 21 items 18-22 (B) p. 16 items 4-9 (D) p. 23 items 32-35 (D) p. 26 items 42-53 (D)
Chapter 14 (Solid State)	Refer to Class Text
Chapter 17	p. 8 items 36-42 (D) p. 20 items 22-23 (D) p. 20 item 49 (A) p. 17 items 22-27 (A) p. 19 items 38-40 (A)
Chapter 22	p. 5 items 16-24 (A) p. 13 items 72-74 (B)
Chapter 23	p. 17 item 10 (D) p. 38 items 28-34 (D) p. 5 items 9-10 (E) p. 21 item 35 (E) p. 26 items 20-26 (E)

APPENDIX C

CHEMISTRY 1015
FIRST HOUR EXAMINATION
FALL, 1968

DIRECTIONS: ONLY ONE of the suggested answers to each question is correct. Select the answer and mark your answer sheet. Also mark your question sheets for your record. USE A #2 SOFT LEAD PENCIL...BE SURE THAT YOU PUT YOUR LABORATORY INSTRUCTOR'S NAME ON THE ANSWER SHEET...SCORE = R-W/3

1. Which of the following is a period of the periodic chart?

   1. Na, Mg, Al, Si, P, S, Cl, Ar
   2. C, Si, Ge, Sn, Pb
   3. Co, Rh, Ir
   4. He, Ne, Cl, Mn, Te, Re

2. Which of the following is a typical nonmetal?

   1. Cs 2. Bi 3. P 4. Mn

3. Which of the following notations indicate the possible <u>sublevels</u> of the <u>main energy level M</u>?

   1. s,p 2. s 3. s,p,d 4. s,p,d,f

4. Mark same answer as in the preceding question.

   1. 2. 3. 4.

5. Elements of similar chemical and physical properties are found in the same ________ of the periodic table.

   1. isotope 2. period 3. group 4. orbital

6. Mark same answer as in the preceding question.

   1. 2. 3. 4.

7. The mass number of aluminum is 27, the atomic number is 13. The number of neutrons in the nucleus is

   1. 40 2. 14 3. 27 4. 13

8. Mark same sanwer as in the preceding question.

   1. 2. 3. 4.

9. The inert gases are characterized by

   1. filled s, incomplete p orbitals
   2. filled s, and filled p orbitals
   3. incomplete s, filled p orbitals
   4. incomplete s orbitals

CHEMISTRY 1015
FIRST HOUR EXAMINATION (continued)

10. If natural potassium is composed of 6.90 per cent of atoms with mass of 40.962 and the rest of the atoms have a mass of 38.964, the atomic weight of K would be

1. 40.962   2. 38.964   3. 41.000   4. 39.102

11. The dot formula for carbon disulfide is:

1. :S̤̈·Ċ·S̤̈:   2. S̤̈::C::S̤̈   3. :S̤̈::C·S̤̈   4. :S̤̈:C:S̤̈:

12. Mark same answer as in the preceding question.

1.   2.   3.   4.

13. Which of the following is not a subatomic particle?

1. photon   2. proton   3. neutron   4. electron

14. Mark same answer as in the preceding question.

1.   2.   3.   4.

15. Neutrons have a mass close to the mass of

1. an alpha particle
2. an electron
3. a proton
4. none of these

16. The atomic numbers of an element represents

1. the number of neutrons and protons present in the atom.
2. the number of neutrons and electrons present in the atom.
3. the number of isotopes for a given atom.
4. the number of portons or electrons present in the atom.

17. Mark same answer as in the preceding question.

1.   2.   3.   4.

18. Which of the following compounds would you expect to exhibit hydrogen bonding?

1. CH_3CH_3 2. HF   3. NaH   4. SO_2

19. There are weak forces of attraction of one molecule for another, even between nonpolar ones. These weak forces are termed

1. coordinate bonds
2. Van der Waal's forces
3. ionic bonds
4. covalent bonds

20. Mark same answer as in the preceding question.

1.   2.   3.   4.

CHEMISTRY 1015
FIRST HOUR EXAMINATION (continued)

21. Knowing the following values for bond energies:

H-H: 104.2 kcal/mol. C-Cl: 78.5 kcal/mol.

Cl-Cl: 58.0 kcal/mol H-Cl: 103.2 kcal/mol.

the calculated heat for the reaction: $1/2\ H_2(g) + 1/2\ Cl_2(g) \rightarrow HCl(g)$ is

1. 44,200 cal
2. 78 kcal
3. 162.2 kcal/mol.
4. 81.1 kcal/mol.

22. Elements with large values of electronegativities are found on the _____ of the periodic chart.

1. inert gas group
2. center
3. top right part
4. bottom left part

23. Mark same answer as in the preceding question.

1. 2. 3. 4.

24. When $_{56}Ba$ reacts with chlorine gas it will

1. lose 2 electrons
2. lose 4 electrons
3. share 2 electrons
4. gain 2 electrons

25. Select the pair of compounds which indicate the same oxidation number for the underlined element.

1. $Na_2\underline{Cr}_2O_7$, $\underline{S}O_3$
2. $\underline{S}O_2$, $\underline{Ca}SO_4$
3. $Ca\underline{C}O_3$, $H_3\underline{P}O_4$
4. $NH_4\underline{Cl}$, $H_3\underline{As}O_3$

26. In the compound CCl_4 the number of electron pairs shared by the carbon is

1. 6 2. 4 3. 8 4. none, compound is ionic

27. Mark same answer as in the preceding question.

1. 2. 3. 4.

28. In the reaction: $2KClO_3 \rightarrow 2Kcl + 3O_2$ the element that

1. is oxidized is potassium
2. is reduced is chlorine
3. gains electrons is oxygen
4. does not change in valence is oxygen

29. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FIRST HOUR EXAMINATION (continued)

30. When the reaction: $Al + H_2SO_4$ is complete and balanced the sum of the coefficients on both sides of the equation is

1. 5   2. 7   3. 9   4. 4

31. Two insoluble compounds you prepared in the laboratory were

1. CuO, $CuCO_3$ 2. $Cu(NO_3)_2$, $Cu(OH)_2$ 3. $CuCl_2$, CuO 4. $CuSO_4$, $CuCl_2$

32. Mark same answer as in the preceding question.

1.   2.   3.   4.

33. When iron rusts it reacts with oxygen and the resulting compound contains Fe(III). The compound is

1. Fe_3O_4 2. Fe_2O 3. Fe_2O_3 4. FeO_2

34. Mark same answer as in the preceding question.

1.   2.   3.   4.

35. Select the compound that is correctly named:

1. $NaHCO_3$ - sodium bicarbonate
2. $KClO_3$ - potassium chloride
3. FeS - fernous sulfate
4. FeO - ferric oxide

36. The compound formed when SO_2 reacts with water is called

1. a salt   2. a base   3. an acid   4. an oxide

37. When the covalent molecule, HCl is dissolved in water one of the products formed is

1. HClO   2. H_3O^+ 3. H_2 4. Cl_2

38. Mark same answer as in the preceding question.

1.   2.   3.   4.

39. When an acid reacts with a base the type reaction is called

1. simple decomposition
2. combination
3. substitution
4. none of these

40. The compound formed when calcium oxide reacts with sulfur dioxide is

1. $CaSO_3$ 2. $Ca(SO_4)_2$ 3. Ca_2SO_3 4. $CaSO_4$

41. Mark same answer as in the preceding question.

1.   2.   3.   4.

CHEMISTRY 1015
FIRST HOUR EXAMINATION (continued)

42. One of the following is not a property of an acid

1. reacts with a base to form a salt and one more product
2. turns blue litmus paper red
3. reacts with active metal to form H_2 and a base
4. reacts with active metals to form a salt and H_2

43. $104^{\circ}F$ (fever temperature) corresponds to what centigrade temperature? (choose nearest answer)

1. 40 2. 36 3. 32 4. 29

44. Mark same answer as in the preceding question.

1. 2. 3. 4.

45. One cubic foot of gas contains how many liters of gas? (choose nearest answer)

1. 22.4 2. 9.30 3. 30.5 4. 28.4

46. If 55.8 grams of iron combine with 32.1 grams of sulfur, how many grams of sulfur will combine with 1.00 gram of iron? (choose nearest answer)

1. 1.00 2. 0.60 3. 1.90 4. 1.70

47. Mark same answer as in the preceding question.

1. 2. 3. 4.

48. If 100 grams of lanthanum combine with 17.3 grams of oxygen, what is the equivalent weight of lanthanum? (choose nearest answer)

1. 70 2. 92 3. 46 4. 16

49. From the problem in Question 48, what is the valence of lanthanum?

1. 1 2. 2 3. 3 4. 4

50. Carbon and oxygen form two principal compounds, carbon monoxide and carbon dioxide. The principal law illustrated is the law of

1. conservation of electrical charge
2. conservation of mass
3. multiple proportions
4. definite proportions

51. Mark same answer as in the preceding question.

1. 2. 3. 4.

52. The weight of one gram mole of H_3PO_4 is (choose nearest answer)

1. 95 2. 98 3. 109 4. 54

CHEMISTRY 1015
FIRST HOUR EXAMINATION (continued)

53. Mark same answer as in the preceding question.

1. 2. 3. 4.

54. How many gram atoms of hydrogen are in one gram mole of H_3PO_4? (choose nearest answer)

1. 31 2. 15 3. 3 4. 1

55. Which of the following reactions is a replacement reaction?

1. $CaSO_4 + MgCO_3 \rightarrow CaCO_3 + MgSO_4$
2. $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$
3. $2H_2O \rightarrow 2H_2 + O_2$
4. $CaO + CO_2 \rightarrow CaCO_3$

56. Mark same answer as in the preceding question.

1. 2. 3. 4.

57. If the composition of an oxide of iron is 77.7 per cent Fe and 22.3 per cent oxygen, what is the empirical formula?

1. FeO_2 2. FeO 3. Fe_3O_4 4. Fe_2O_3

58. How many grams of oxygen are required to react with one mole of H_2S in the balanced reaction $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$ (choose nearest answer)

1. 24 2. 32 3. 48 4. 16

59. Mark same answer as in the preceding question.

1. 2. 3. 4.

60. A kilogram of metallic osmium occupies a volume of 44.5 ml. What is the density of osmium in grams per ml? (choose nearest answer)

1. 28 2. 25 3. 26 4. 22

CHEMISTRY 1015
SECOND HOUR EXAMINATION
FALL, 1968

DIRECTIONS: ONLY ONE of the suggested answers to each question is correct. Select the answer and mark your answer sheet. MARK ONE RESPONSE ONLY. Also mark your question sheets for your record. USE A #2 SOFT LEAD PENCIL. Be sure that you put your LABORATORY instructor's name on the answer sheet. SCORE = R-W/3

ACTIVITY SERIES

K
Ba
Ca
Na
Mg
Al
Mn
Zn
Cr
Cd
Fe
Co
Ni
Sn
Pb
Hydrogen
Sb
Bi
As
Cu
Hg
Ag
Pt
Au

1. To precipitate the $SO_4^=$ ion from an aqueous solution of a soluble salt you would add

   1. $BaCl_2$ 2. NaOH   3. Cl_2 4. $Al(NO_3)_3$

2. Mark same answer as in the preceding question.

   1.   2.   3.   4.

3. When silver nitrate reacts with hydrochloric acid the ionic equation is

   1. $AgNO_3 + HCl \rightarrow AgCl + HNO_3$

   2. $Ag^+ + NO_3^- + H^+ + Cl^- \rightarrow Ag^+ + Cl^- + H^+ + NO_3^-$

   3. $AgNO_3 + H^+ + Cl^- \rightarrow AgCl + H^+ + NO_3$

   4. $Ag^= + NO_3^- + H^+ + Cl^- \rightarrow AgCl + H^+ + NO_3^-$

4. When an acid is added to a carbonate the gas formed is

   1. H_2 2. CO   3. CO_2 4. O_2

5. Mark same answer as in the preceding question.

   1.   2.   3.   4.

6. When Cu was heated in air a compound containing 88.89 per cent Cu and 11.11 per cent oxygen was found. The formula is (Cu = 64)

   1. CuOH   2. Cu_2O 3. CuO_2 4. CuO

7. The percentage of sulfur in FeS_2 is about (S = 32)

   1. 26.7%   2. 53.3%   3. 46.6%   4. 93.3%

8. Mark same answer as in the preceding question.

   1.   2.   3.   4.

9. When Al metal is added to $CuSO_4$ solution

   1. the solution turns blue
   2. there is no reaction

CHEMISTRY 1015
SECOND HOUR EXAMINATION (continued)

9. 3. there is a precipitate formed
4. the solution loses its color

10. Mark the same answer as in the preceding question.

1. 2. 3. 4.

11. All but one of the following factors influence the rate of hydrogen displacement from acids by metals.

1. activity of the metal
2. temperature
3. number of hydrogen atoms in acid
4. the strength of the acid

12. When chlorine water is added to a solution of potassium iodide

1. the chlorine is oxidized
2. the product will give an orange color in CCl_4
3. the element iodine will be formed

13. The element that will displace only one-half the hydrogen in the water molecule is

1. Cu 2. Ca 3. Al 4. Fe

14. Mark same answer as in the preceding question.

1. 2. 3. 4.

15. The gas that is collected in the laboratory over water is

1. NH_3 2. O_2 3. HCl 4. CO_2

16. When H_2 is passed over hot copper (II) oxide,

1. the reducing agent is Copper (II) oxide
2. the oxygen is the oxidizing agent
3. there is no change in the valence of the copper
4. the hydrogen is the reducing agent

17. Mark same answer as in the preceding question.

1. 2. 3. 4.

18. When concentrated NaOH is added to Al metal a product formed is

1. H_2 2. Al_2O_3 3. H_2O 4. $Al(OH)_3$

19. The compound that will produce the greatest per cent of oxygen per mole when heated is

1. $KClO_3$ 2. H_2O 3. HgO 4. PbO_2

20. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
SECOND HOUR EXAMINATION (continued)

21. The element that will form only a dioxide when burned in oxygen without a catalyst is

1. P 2. H 3. S 4. Fe

22. Which of the following metals would displace Cu from a solution of copper sulfate?

1. Hg 2. Au 3. Ag 4. Mn

23. Mark same answer as in the preceding question.

1. 2. 3. 4.

24. Which of the following denotes an isotope of hydrogen?

1. ${}_1H^{1.008}$ 2. ${}_2H^1$ 3. ${}_1H^3$ 4. ${}_3H^1$

25. Metallic copper plus hot concentrated nitric acid most likely gives

1. hydrogen 2. oxygen 3. nitrogen dioxide
4. sulfate ion

26. The following is a reversible reaction:

$$3Fe + 4H_2O\ (Steam) \rightleftarrows Fe_3O_4 + 4H_2$$

Which of the following pairs act as oxidizing agent in the above reaction?

1. Fe, H_2O 2. Fe_3O_4, H_2 3. Fe, H_2 4. H_2O, Fe_3O_4

27. 100 liters of a gas at 27 C and 700 mm Hg pressure would occupy what volume at STP? (choose closest answer)

1. 84 liters 2. 840 cm^3 3. 840 ml 4. 80 liters

28. Mark same answer as in the preceding question.

1. 2. 3. 4.

29. A sealed vessel containing methane at 730 mm and 27 C is put into a box cooled with "dry ice" (-78 C). What pressure will the gas exert under these conditions? (Assume constant volume).

1. 1120 mm 2. 475 mm 3. 112 mm 4. 625 mm

30. The major difference between the gaseous state and the liquid state is

1. weight of the particles
2. size of the container
3. distance of separation of the particles
4. size of the particles

CHEMISTRY 1015
SECOND HOUR EXAMINATION (continued)

31. Mark same answer as in the preceding question.

1. 2. 3. 4.

32. Under usual laboratory working conditions of pressure and temperature, most gases

1. conform fairly closely to ideal behavior
2. do not follow Dalton's law of partial pressure alone
3. follow Boyle's law but do not follow Charles' law
4. follow Charles' law but do not follow Boyle's law

33. The state of matter where the molecules are relatively close together, randomly organized and in constant motion is

1. solid 2. crystalline 3. gaseous 4. liquid

34. Mark same answer as in the preceding question.

1. 2. 3. 4.

35. The vapor pressure of a pure liquid depends mainly upon

1. the pressure
2. the temperature
3. the enthalpy
4. the presence of a catalyst

36. At the boiling point for any liquid, it is always true that

1. vapor pressure equals the external pressure
2. vapor pressure is normal
3. temperature is 100 C
4. liquid is in non-equilibrium

37. Mark same answer as in the preceding question.

1. 2. 3. 4.

38. 1.222 g of a hydrate of barium chloride on being heated gives 0.180 of H_2O. The formula for the hydrate is

1. $Ba_2Cl_2 \cdot 2H_2O$
2. $BaCl_2 \cdot 2H_2O$
3. $Ba_2Cl \cdot H_2O$
4. $BaCl_2 \cdot H_2O$

39. A crystal which absorbs moisture to form a solution is termed

1. anhydrous
2. efflorescence
3. deliquescent
4. volatile

40. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
SECOND HOUR EXAMINATION (continued)

41. The compounds N_2O_5, H_2SeO_4, $AlPO_4$, $Sn(OH)_2$ are classified in order
   1. base, salt, acid anhydride, mixed salt
   2. acid anhydride, acid, salt, base
   3. acid anhydride, mixed salt, salt, basic anhydride
   4. basic anhydride, salt, acid anhydride, base

42. The compounds Fe_2O_3, $SnCl_2$, $NaHCO_3$ are named in order
   1. ferric oxide, stannous chloride, sodium bicarbonate
   2. ferrous oxide, stannous chloride, sodium bicarbonate
   3. ferric oxide, stannic chloride, sodium bicarbonate
   4. ferric oxide, stannous chloride, sodium carbonate

43. The compound, $LiIO_2$ is named
   1. lithium iodate
   2. lithium iodide
   3. lithium iodite
   4. lithium hypoiodite

44. The compound $HClO_3$ is named
   1. perchloric acid
   2. chloric acid
   3. hydrochloric acid
   4. chlorous acid

45. Mark same answer as in the preceding question.
   1. 2. 3. 4.

46. When aluminum hydroxide reacts with hydrobromic acid, the sum of the coefficients in the balanced chemical reaction is
   1. 7 2. 8 3. 9 4. 10

47. Mark same answer as in the preceding question.
   1. 2. 3. 4.

48. How many grams of water are formed when 24 g of hydrogen are burned in oxygen (choose nearest correct answer)
   1. 185 2. 200 3. 215 4. 230

49. How many grams of HCl may be obtained by heating 117 g of NaCl with H_2SO_4? (choose nearest answer)
   1. 60 2. 70 3. 80 4. 90

50. What volume of hydrogen at STP will be formed by 46 g of sodium reacted with water? (choose nearest answer)
   1. 10 liters 2. 20 liters 3. 30 liters 4. 40 liters

51. Predict the most probable product on reaction of Si with O_2.
   1. SiO_2 2. SiO 3. Si_2O 4. Si_2O_3

CHEMISTRY 1015
SECOND HOUR EXAMINATION (continued)

52. Mark same answer as in the preceding question.

1. 2. 3. 4.

53. How many moles of aluminum oxide can be formed when 0.25 moles of aluminum react with excess O_2? (choose nearest answer)

1. 0.1 mole 2. 0.25 mole 3. 0.37 mole 4. 0.50 mole

54. Mark same answer as in the preceding question.

1. 2. 3. 4.

55. At STP how many liters of HCl may be obtained by reacting 22.4 liters of hydrogen with excess chlorine? (choose nearest answer)

1. 25 2. 35 3. 45 4. 55

56. Mark same answer as in the preceding question.

1. 2. 3. 4.

57. Which of the following is <u>not</u> a useful preparation of oxygen?

1. HgO + heat $\rightarrow$
2. $KClO_3$ + heat (MnO_2 catalyst) $\rightarrow$
3. CO_2 + heat $\rightarrow$
4. H_2O (electrolysis) $\rightarrow$

58. Mark same answer as in the preceding question.

1. 2. 3. 4.

59. Which of the following metal oxides is too stable on heating to be used for the preparation of oxygen?

1. HgO 2. ZnO 3. PbO_2 4. Ag_2O

60. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FINAL EXAMINATION
FALL, 1968

DIRECTIONS: ONLY ONE of the suggested answers to each question is correct. Select the answer and mark your answer sheet. MARK ONE RESPONSE ONLY. Also mark your question sheets for your record. USE A #2 SOFT LEAD PENCIL. Be sure that you put your LABORATORY instructor's name on the answer sheet. SCORE = R-W/3

1. Upon heating ammonium nitrate, the gas formed is

   1. N_2 2. N_2O 3. NO 4. N_2O_3

2. Mark the same answer as in preceding question.

   1. 2. 3. 4.

3. For a laboratory preparation of nitrogen, one satisfactory starting material is

   1. HNO_3 2. Mg_3H_2 3. $NaNO_2$ 4. $Pb(NO_3)_2$

4. Which of the following is not an oxidation state of nitrogen?

   1. (-3) 2. (+7) 3. (+3) 4. (+5)

5. Mark same answer as in the preceding question.

   1. 2. 3. 4.

6. The action of water on a nitride produces

   1. $N_2(g)$ 2. NH_4Cl 3. $NH_3(g)$ 4. HNO_3

7. Mark same answer as in the preceding question.

   1. 2. 3. 4.

8. The statement: $N_2 + O_2 \xrightarrow{\text{electric discharge}} 2NO$ H = +43,200 cal gives the following information:

   1. the reaction is slow
   2. the reaction is fast
   3. the reaction is exothermic
   4. the reaction is endothermic

9. Mark same answer as in the preceding question.

   1. 2. 3. 4.

10. The preferred equation describing the equilibrium existing in an aqueous solution of ammonia is

    1. $NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$
    2. $NH_4OH \rightleftarrows NH_4^+ + OH^-$
    3. $NH_3 + H_2O \rightleftarrows NH_4OH$
    4. $NH_4OH \rightleftarrows NH_3 + OH_2$

CHEMISTRY 1015
FINAL EXAMINATION (continued)

11. How many atoms or groups in the unit cell of a simple cubic lattice?

1. 8 2. 9 3. 12 4. 14

12. Mark same answer as in the preceding question.

1. 2. 3. 4.

13. Which of the following terms normally would not describe a crystalline material?

1. atoms are arranged in a repeating geometric pattern
2. transition from solid to liquid is sharp and distinct
3. material is amorphour
4. spacing between crystal planes is regular

14. Mark same answer as in preceding question.

1. 2. 3. 4.

15. The maximum density of water is found at what temperature? (choose nearest answer)

1. 0 C 2. 4 F 3. 4 C 4. 34 F

16. Mark same answer as in preceding question.

1. 2. 3. 4.

17. If the heat of vaporization of water is 539 cal/g, how many calories of heat are required to convert 1 g of water at 25 C to 1 g of steam at 100 C? (choose nearest answer)

1. 273 2. 539 3. 565 4. 615

18. Mark the same answer as in preceding question.

1. 2. 3. 4.

19. A liquid is heated in a closed vessel until boiling ceases. Which one of the following statements is the least correct?

1. Evaporation and condensation are taking place at the same rate
2. Equilibrium has been established
3. The vapor pressure of the liquid is equal to the pressure of the gas above the liquid
4. The pressure of the gas is 760 mm

20. Free iodine is fairly insoluble in water. Adding which of the following compounds to the mixture will solubilize iodine in water?

1. $CaCl_2$ 2. turpentine 3. $SbCl_3$ 4. NaI

CHEMISTRY 1015
FINAL EXAMINATION (continued)

21. Mark same answer as in the preceding question.

1. 2. 3. 4.

22. The half-reaction: $2Cl^- \rightarrow Cl_2 + 2e$ is an example of

1. equilibrium
2. reduction
3. sublimation
4. oxidation

23. Mark same answer as in the preceding question.

1. 2. 3. 4.

24. Select the most powerful oxidizing agent.

1. O_2 2. Br_2 3. I_2 4. F_2

25. HI can not be prepared from KI and conc H_2SO_4 because

1. the HI has a high boiling point
2. KI is too stable
3. conc H_2SO_4 is a reducing agent
4. conc H_2SO_4 oxidizes the I^- to iodine

26. Mark same answer as in preceding question.

1. 2. 3. 4.

27. Select the reaction that will take place.

1. $Br_2 + 2NaI \rightarrow 2NaBr + I_2$
2. $Cl_2 + CaF_2 \rightarrow CaCl_2 + F_2$
3. $CaCl_2 + I_2 \rightarrow CaI_2 + Cl_2$
4. $4HF + O_2 \rightarrow 2H_2O + 2F_2$

28. Mark same answer as in preceding question.

1. 2. 3. 4.

29. F_2 may be released from HF by

1. conc H_2SO_4 2. $KMnO_4$ 3. Cl_2 4. Electrolysis

30. When an electric current is passed through NaCl solution

1. the positive ion is called the anion
2. hydrogen gas is evolved at the anode
3. each chloride ion gains two electrons
4. the negative ion moves to the anode

31. Chlorine reacts slowly with water to form

1. HClO and $HClO_2$
2. HCl and HClO
3. HCl and $HClO_3$
4. $HClO_3$ and HClO

32. Mark the same answer as in preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FINAL EXAMINATION (continued)

33. HF reacts with SiO_2 to form soluble silicon tetrafluoride and one more product. When the reaction is complete the sum of the coefficients on both sides of the equation is

1. 4 2. 8 3. 6 4. 10

34. Which of the following notations indicate the possible sublevels of the main energy level L?

1. s,p 2. s 3. s,p,d 4. s,p,d,f

35. Mark same answer as in the preceding question.

1. 2. 3. 4.

36. The mass number of Gallium is 70, the atomic number is 31. The number of neutrons in the nucleus is

1. 40 2. 39 3. 31 4. 101

37. Mark same answer as in the preceding question.

1. 2. 3. 4.

38. The dot formula for carbon tetrachloride is

```
       Cl              Cl              Cl              Cl
       ••              •               •               ••
1.  Cl:C•Cl    2.  Cl•C•Cl    3.  Cl::C:Cl    4.  Cl:C:Cl
       •               •               ,               ••
       Cl              Cl              Cl              Cl
```

39. Mark same answer as in the preceding question.

1. 2. 3. 4.

40. Four neutrons have a mass close to the mass of

1. an alpha particle
2. an electron
3. a proton
4. none of these

41. Mark same answer as in the preceding question.

1. 2. 3. 4.

42. Which of the following compounds would you expect to exhibit hydrogen bonding?

1. CH_3CH_3 2. H_2O 3. NaOH 4. SO_2

43. When ${}_{13}Al$ reacts with chlorine gas it will

1. lose 3 electrons
2. lose 1 electron
3. share 3 electrons
4. gain 3 electrons

44. Mark same answer as in preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FINAL EXAMINATION (continued)

45. Select the pair of compounds which indicate the same oxidation number for the under-lined element.

1. $K\underline{Mn}O_4$ $\underline{Cl}_2O_7$ 2. $\underline{S}O_2$ $Ca\underline{S}O_4$ 3. $Ca\underline{C}O_3$ $H_3\underline{P}O_4$ 4. $NH_4\underline{Cl}$ $H_3\underline{As}O_3$

46. Two insoluble compounds you prepared in the laboratory were

1. $Cu(OH)_2$ $CuCO_3$ 2. $Cu(NO_3)_2$ $Cu(OH)_2$ 3. $CuCl_2$ CuO 4. $CuSO_4$ $CuCl_2$

47. Mark same answer as in the preceding question.

1. 2. 3. 4.

48. When iron rusts it reacts with oxygen and the resulting compound contains Fe(III). The compound is

1. Fe_3O_4 2. Fe_2O 3. Fe_2O_3 4. FeO_2

49. Mark same answer as in the preceding question.

1. 2. 3. 4.

50. The compound formed when CaO reacts with water is called

1. a salt 2. a base 3. an acid 4. an oxide

51. Mark same answer as in preceding question.

1. 2. 3. 4.

52. When the covalent molecule, HBr is dissolved in water one of the products formed is

1. HBrO 2. H_3O^+ 3. H_2 4. Br_2

53. The compound formed when sodium oxide reacts with sulfur dioxide

1. Na_2SO_4 2. $NaHSO_3$ 3. Na_2SO_3 4. $Na_2S_2O_3$

54. Mark same answer as in the preceding question.

1. 2. 3. 4.

55. 104 F corresponds to what centigrade temperature? (choose nearest answer)

1. 40 2. 36 3. 32 4. 29

56. If 55.8 g of iron combine with 32.1 g of sulfur, how many grams of sulfur will combine with 1.00 g of iron (choose nearest answer)

1. 1.00 2. 0.60 3. 1.90 4. 1.70

CHEMISTRY 1015
FINAL EXAMINATION (continued)

57. Mark same answer as in the preceding question.

1. 2. 3. 4.

58. If 130 g of Zn combine with 32 g of oxygen, what is the equivalent weight of Zn? (choose nearest answer)

1. 32.5 2. 16 3. 8 4. 65

59. Mark same answer as in the preceding question.

1. 2. 3. 4.

60. The weight of one gram mole of $K_2Cr_2O_7$ is (choose nearest answer)

1. 294 2. 242 3. 255 4. 289

61. 1/2 kg of metallic Pb occupies a volume of 44.0 ml. What is the density of Pb in grams per milliliters? (choose nearest answer)

1. 11 2. 8 3. 14 4. 22

62. Mark same answer as in the preceding question.

1. 2. 3. 4.

63. Which of the following metals would displace Bi from a solution of $BiCl_3$?

1. Pb 2. Cu 3. Au 4. Hg

64. Mark same answer as in the preceding question.

1. 2. 3. 4.

65. Metallic copper plus dil. nitric acid most likely gives

1. hydrogen 2. nitrogen dioxide 3. nitric oxide 4. Oxygen

66. The following is a reversible reaction:

$$3Fe + 4H_2O \text{ (steam)} \rightleftarrows Fe_3O_4 + 4H_2$$

Which of the following pairs act as reducing agents in the reaction?

1. Fe, H_2 2. H_2O, Fe_3O_4 3. Fe, H_2O 4. Fe_3O_4, H_2

67. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FINAL EXAMINATION (continued)

68. 200 liters of a gas at 27 C and 700 mm Hg pressure would occupy what volume at STP? (choose nearest answer)

1. 1840 ml 2. 160 liters 3. 168 liters 4. 840 cm^3

69. Mark same answer as in the preceding question.

1. 2. 3. 4.

70. The state of matter where the molecules are relatively far apart, and in constant motion is

1. liquid 2. gaseous 3. crystalline 4. solid

71. 1.00 g of a hydrate of magnesium sulfate on being heated gives 0.512 g of H_2). The formula for the hydrate is

1. $MgSO_4 \cdot H_2O$
2. $Mg_2SO_4 \cdot H_2O$
3. $MgSO_4 \cdot 5H_2O$
4. $MgSO_4 \cdot 7H_2O$

72. Mark same answer as in the preceding question.

1. 2. 3. 4.

73. A crystal which gives off moisture to the air is termed

1. deliquescent
2. volatile
3. efflorescence
4. anhydrous

74. The compounds CaO, H_2SeO_4, $AlPO_4$, $Sn(OH)_2$ are classified in order

1. basic anhydride, salt, acid anhydride, base
2. acid anhydride, mixed salt, salt, basic anhydride
3. basic anhydride, acid, salt, base
4. base, salt, acid anhydride, mixed salt

75. Mark same answer as in the preceding question.

1. 2. 3. 4.

76. The compounds Fe_2O_3, $SnCl_2$, $Ca(HCO_3)_2$ are named in order

1. ferric oxide, stannous chloride, calcium carbonate
2. ferric oxide, stannic chloride, calcium bicarbonate
3. ferrous oxide, stannous chloride, calcium bicarbonate
4. ferric oxide, stannous chloride, calcium bicarbonate

77. Mark same answer as in the preceding question.

1. 2. 3. 4.

CHEMISTRY 1015
FINAL EXAMINATION (continued)

78. The compound, LiIO is named

1. lithium iodide
2. lithium iodate
3. lithium hypoiodite
4. lithium iodite

79. Mark same answer as in the preceding question.

1. 2. 3. 4.

80. The compound, $HClO_2$ is named

1. chloric acid
2. hydrochloric acid
3. chlorous acid
4. perchloric acid

81. When calcium hydroxide reacts with phosphoric acid, the sum of the coefficients in the balanced chemical reaction is

1. 9 2. 10 3. 8 4. 12

82. Mark same answer as in the preceding question.

1. 2. 3. 4.

83. How many grams of water are formed when 64 g O_2 react with H_2? (choose nearest answer)

1. 44 2. 36 3. 72 4. 18

84. Mark same answer as in the preceding question.

1. 2. 3. 4.

85. How many grams of Na_2SO_4 may be obtained by heating 117 g of NaCl with H_2SO_4? (choose nearest answer)

1. 190 2. 284 3. 142 4. 234

86. What volume of hydrogen at STP will be formed by 92 g of sodium reacted with water? (choose nearest answer)

1. 23 liters 2. 90 liters 3. 45 liters 4. 50 liters

87. Mark same answer as in the preceding question.

1. 2. 3. 4.

88. How many moles of Iron (III) oxide can be formed when 0.8 moles of Fe react with excess O_2? (Choose nearest answer)

1. 1.6 mole 2. 0.35 mole 3. 0.8 mole 4. 0.4 mole

CHEMISTRY 1015
FINAL EXAMINATION (continued)

89. At STP how many liters of HCl may be obtained by reacting 44.8 liters of hydrogen with excess chlorine? (choose nearest answer)

1. 55 2. 45 3. 25 4. 90

90. Mark same answer as in the preceding question.

1. 2. 3. 4.

91. Which of the following is <u>not</u> a useful preparation of oxygen?

1. H_2O (electrolysis) → 3. $KClO_3$ + heat (MnO_2 catalyst) →
2. SO_3 + heat → 4. PbO_2 + heat →

92. Mark same answer as in the preceding question.

1. 2. 3. 4.

93. When an acid is added to $NaHCO_3$ the gas formed is

1. CO 2. CO_2 3. O_2 4. H_2

94. Mark same answer as in the preceding question.

1. 2. 3. 4.

95. When Cu was heated in air a compound containing 88.89 per cent Cu and 11.11 per cent oxygen was formed. The formula is (Cu = 64)

1. CuO 2. CuO_2 3. Cu_2O 4. CuOH

96. The percentage of oxygen in Na_2SO_4 is about

1. 90% 2. 45% 3. 32% 4. 51%

97. Mark same answer as in the preceding question.

1. 2. 3. 4.

98. When Cu metal is added to $ZnSO_4$ solution

1. the solution loses its color 3. the solution turns blue
2. there is a precipitate formed 4. there is no reaction

99. Mark same answer as in the preceding question.

1. 2. 3. 4.

100. When H_2 is passed over hot copper(II) oxide

1. the oxygen is the oxidizing agent
2. the reducing agent is copper(II) oxide
3. the hydrogen is the oxidizing agent
4. the copper in the copper oxide gains 2 electrons

APPENDIX D

CHEMISTRY 1015 - MINIMUM ATTAINMENT TEST #1

NAME____________________ LAB DAY_________ LAB INSTRUCTOR_________

(2) 1. Circle the subatomic particles appearing in the following:

ion   isotope   proton   neutron   element

(2) 2. Indicate the maximum number of electrons needed to fill the 4th main energy level. __________

(2) 3. What is the maximum number of electrons in a d sublevel?

____

(5) 4. Write symbol and ionic valence for:

Magnesium __________ Sulfur __________

Iron(II) __________ Copper(I) __________

Iodine __________

(3) 5. Write the chemical formula of

Acetic acid __________ Carbonic acid __________

Sulfuric acid __________

(3) 6. Write (including charge) the formula of:

Ammonium ion __________ Sulfate ion __________

Acetate ion __________

(2) 7. Complete and balance:

$Cu^{++} + OH^{-} \rightarrow$ ____________________

$NH_4^{+} + SO_4 \rightarrow$ ____________________

(2) 8. Mark all the oxides in the following list:

$FeCl_2$ $Ca(OH)_2$ Cu_2O NaOH   BaO

(2) 9. Mark all the acids in the following list:

$SnCl_2$ HNO_3 KI H_2S Na_2CO_3

(2) 10. Mark all the salts in the following list:

Na_2CO_3 BaO   NaOH Fe_2O_3 $SnCl_2$

CHEMISTRY 1015 - MINIMUM ATTAINMENT TEST #2

NAME________________ LAB DAY________ LAB INSTRUCTOR________

(1) 1. Neutralization is the reaction between an acid and ______
1. a salt 2. a polar bond 3. a base 4. a ionic bond

(2) 2. Give a brief idea of (a) hydrogen bond OR (b) oxide

(10) 3. Classify as acid, base, etc., and NAME the following compounds:

	TYPE	NAME
(a) $Ca(OH)_2$	______	______
(b) $SnCl_2$	______	______
(c) HNO_3	______	______
(d) Fe_2O_3	______	______
(e) $NaHCO_3$	______	______

(8) 4. Complete and balance each of the following equations:

$H_2SO_4 + KOH \rightarrow$

$Ca(OH)_2 + H_3PO_4 \rightarrow$

$KClO_3 + heat \rightarrow$

$CaO + CO_2 \rightarrow$

(2) 5. How many grams of CO_2 will be formed from 48 g of carbon when carbon is reacted with oxygen? SHOW YOUR WORK

(2) 6. A compound contains 11.1 per cent of hydrogen and 88.9 per cent of oxygen. Find the empirical formula. SHOW YOUR WORK

CHEMISTRY 1015 - MINIMUM ATTAINMENT TEST #3

NAME______________________ LAB DAY________ LAB INSTRUCTOR____________

(3) 1. In the following chemical reaction, $Zn + H_2SO_4 \quad ZnSO_4 + H_2$ the oxidizing agent is ______________________.

(2) 2. Define catalyst:

(4) 3. Which of these reactions will result in the release of a metal from its compound? (Complete and Balance)

$Cu + HCl \longrightarrow$

$ZnSO_4 + Cu \longrightarrow$

$AgNO_3 + Cu \longrightarrow$

(2) 4. Give a complete and balanced equation for a reaction by which oxygen is prepared in the laboratory.

(6) 5. Complete and balance: $Ca(OH)_2 + H_2CO_3 \longrightarrow$

$SO_3 + HOH \longrightarrow$

$K_2O + SO_2 \longrightarrow$

(2) 6. Temperature is a measure of

(a) potential energy of the molecules __________
(b) bonding in molecules __________
(c) kinetic energy of molecules __________
(d) none of these __________

(6) 7. Set up the solution for the following problems:

(a) What final pressure must be applied to a sample of gas having a volume of 200 ml at 20 C and 750 mm pressure to permit the expansion of the gas to a volume of 600 ml at 20 C? What gas law do you apply?

(b) A sample of gas occupies 200 ml at 10 C and 740 mm pressure. What volume will the gas have at 20 C and 750 mm? What gas law do you apply?

APPENDIX E

CHEMISTRY 1015 QUESTIONNAIRE

LAB INSTRUCTOR_______________ FRESHMAN SOPHOMORE JUNION SENIOR

DIRECTIONS: Check the response which is appropriate in answering the following question:

1. Are you aware that the material taught in Chemistry 1015 is available to be studied in programed form:

   YES NO

DIRECTIONS: If your answer to #1 is yes, please answer the following:

2. To what degree did you use the programed materials?
   a. frequently (more than 10 times)
   b. occasionally (more than 5 but less than 10 times)
   c. very little
   d. did use but less than 5 times
   e. did not use at all

3. How did you become aware of the existence of these materials?
   a. instructor's advice
   b. fellow students
   c. found in the library on my own
   d. purchased in the bookstore because of the course title

4. I found that the programed material affected my study in the following way:
   a. shortened my study time
   b. lengthened my study time
   c. had no effect at all on my study time

DIRECTIONS: In the following questions number the items in the order of their importance, make the most important number one.

5. If I were to classify the most valuable aid to me in the course, I would choose
   a. programed material
   b. teacher conferences
   c. the textbook for the course

6. Since I have used programed materials I would say I
   a. like it
   b. do not like it
   c. no feeling about it at all

7. Any further comments:

CHEMISTRY 1225 QUESTIONNAIRE

1. When did you meet your laboratory class for Chemistry 1015 during the Fall Semester of 1968? ______________________________

DIRECTIONS: IN THE FOLLOWING QUESTIONS UNDERSCORE THE APPROPRIATE ANSWER.

2. Did you use the supplementary programed chemistry material (5 volumes) in Chemistry 1015? YES NO

3. Have you been using the supplementary programed chemistry material in Chemistry 1225? YES NO

VITA

Alfred Franklin Young

Candidate for the Degree of

Doctor of Education

Thesis: A COMPARATIVE STUDY OF SUPPLEMENTARY PROGRAMED AND CONVENTIONAL METHODS OF INSTRUCTION IN TEACHING FRESHMAN CHEMISTRY 1015 AT OKLAHOMA STATE UNIVERSITY

Major Field: Higher Education

Biographical:

Personal Data: Born on April 14, 1932, in Clanton, Alabama, the son of Rev. and Mrs. George R. Young, Sr.

Education: Graduated from George W. Carver High School, Dothan, Alabama, in 1950; received the Bachelor of Science degree with a major in science and a minor in mathematics from Alabama State College, Montgomery, Alabama, in 1957; received the Master of Science degree with a major in chemistry from Atlanta University, Atlanta, Georgia, in 1963; participated in National Science Foundation Summer Institutes at Atlanta University, Atlanta, Georgia, from 1959 through 1962 and the 1959-60 National Science Foundation academic year institute at Atlanta University; studied as a Charles F. Kettering Fellow at Western Michigan University, Kalamazoo, Michigan, summer, 1965; completed requirements for the Doctor of Education degree at Oklahoma State University in May, 1970.

Professional Experience: Science teacher at East Highland High School, Sylacauga, Alabama, 1957 through 1958; science teacher at G. W. Carver High School, Montgomery, Alabama, 1958 through 1963; assistant professor of chemistry at Benedict College from 1963 until present; graduate assistant in the Department of Chemistry at Oklahoma State University, 1967 through 1968.