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A COMPARISON OF TWO METHODS OF TEACHING CHEMISTRY TO FRESHMAN STUDENT NURSES: AN INDIVIDUALIZED APPROACH VERSUS LECTURE

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Field of Science Education

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CHAPTER I

THE PROBLEM

Student nurses are generally required to take a course in chemistry as part of their nursing education. Students enter this course with significant differences in preparation and ability. At one extreme are the more able students with excellent preparation in chemistry, and at the other extreme are the less able students with very limited preparation. The result of this situation is that many more students than necessary are either unable to master the necessary chemical concepts or are not challenged by the course as they should be.

The method of instruction that is most often used in teaching chemistry to student nurses is the lecture. Using this method often makes it difficult to adjust curriculum materials to meet individual needs or to provide individual help to students. A more flexible method is needed so that a greater number of students will benefit from the course in chemistry.

Although various types of individualized instruction have been proposed by many persons, relatively few real experimental studies have compared such methods to the more traditional lecture method. No studies have been reported in which instruction in chemistry for student nurses was individualized and then compared to the lecture approach. The problem is to determine if an individualized approach can be used in a chemistry course for student nurses without sacrificing academic achievement.

Purpose of the Study

The primary purpose of this study was to determine if the academic achievement of a class of freshman student nurses taking chemistry would be affected by using a technique of individualized instruction which utilized a learning guide and small group discussion. Possible effects were determined by comparing this class with one taught by the traditional lecture method.

A second purpose of this study was to determine if the use of this method of individualized instruction would affect students' attitude toward chemistry when compared with the attitude of students taught by the lecture method.

Background of the Study

Individualized instruction has long been recognized as an important part of education. Educators today consider the individualization of instruction to be a necessary goal of the educational process. Current literature is encouraging the development of programs and techniques of instruction that will provide for the varied learning needs of the individual students.

For the past three years the author has tried to individualize instruction in his chemistry course for freshman student nurses. After using the conventional lecture approach along with ability grouping in the laboratory, he tried to use a combination of lecture and self-study. Students worked through a teacher-prepared learning guide at assigned times and attended a reduced number of lectures. Both required and optional learning materials were provided.

Students seemed to react very favorably to this method of learning chemistry. They particularly liked having greater interaction among members of the class as they worked on the learning guide, having the instructor available in an informal setting to help with special problems, and having essential and optional material differentiated.

No obvious differences appeared in academic achievement in chemistry using the two methods. Student attitude toward the experimental method, however, seemed more favorable. Because this was not a controlled experimental study, the author decided to refine the method and compare it to the previously used lecture method.

Design of the Study

A method of individualized instruction which utilized a learning guide and group discussion was compared to the lecture method of teaching chemistry. The experiment was conducted in the normal lecture portion of a twelve week chemistry course for freshman student nurses, involving two hours per week. The laboratory portion of the course was not included in the experiment. Students were assigned randomly to the treatment group. Additional aspects of the study are enumerated below.

1. Control Group. The method of instruction used with the control group was the lecture. The role of the instructor in the control group was to: (1) explain concepts and principles of chemistry by means of the lecture, (2) answer questions from the class as they arose, and (3) make available resource materials that would be appropriate for learners of different abilities. Students in the control group met for two one-hour lectures each week.

2. Treatment Group. The method of instruction used with the treatment group was individualized instruction with group discussion. Students in the treatment group worked individually through a teacher-prepared learning guide during a weekly two-hour work session. The learning guide contained written explanations of chemical principles and concepts, questions to be answered and problems to be solved. An example of a unit from the learning guide appears in Appendix A.

The learning guide consisted of two parts. The first part was required of all students, and knowledge of this material was necessary for C-level achievement. The first part also included reference to review materials which could be used by students with poor chemistry backgrounds. The second part of the guide was optional, and contained learning materials for those students who could master the required material quickly. In the second part certain aspects of the general topic that were taken up in the first part could be studied in greater depth. Some knowledge of this material was expected of A and B students.

All students in the treatment group received both parts of the learning guide. Students worked in heterogeneous small groups of four or five members on the learning guide for approximately the first one hour and thirty minutes of the two-hour session. During this time the students worked individually, but were also expected to help students in their group who were having difficulty. The heterogeneous groups were set up so that stronger students could give assistance to weaker students when it was needed. At the end of the one hour and thirty minute session, students broke up into homogeneous small groups for discussions of the topic that they were studying. A discussion leader for each group was chosen by the instructor each week. The purpose of the discussion was to clarify any concepts still not understood. The instructor had prepared lists of questions which the students could use to assess their knowledge of the subject. The length of time involved in this discussion varied with the knowledge and ability of the students in the particular group. When the discussion was completed, the students continued to work on the learning guide. After the required work was completed satisfactorily, students began working on the optional materials.

Students kept the learning guide with them and were able to study on their own after the two-hour class was over. A key, with the correct answers to questions and solutions to problems, was available to the students in the library at the end of each week.

The role of the instructor in the treatment group was to assist students as they worked through the learning guide and as they assessed their progress in the discussion sessions. The instructor was present during the entire two-hour session to assist students, but he did not lecture to the treatment group.

3. Both groups were taught by the same instructor.

4. Both the treatment and control groups received the same list of questions to assess their knowledge of the required and optional materials. The treatment group used these in organized discussion groups and the control group used these on their own. Correct answers to the questions were posted at the end of each week. An example of the Assessment Questions appears in the sample unit in Appendix A.

5. Each week the two groups received the same list of topics to be studied along with specific references for each topic. An example of a list of topics is also included in the sample unit in Appendix A.

6. Both groups had material differentiated into that which was required (for C-level achievement) and that which was optional (required for A and B-level achievement). The treatment group received this material from the learning guide and the control group received this material from the lectures.

7. Each week both groups received the same list of objectives which were related to the topic being studied (see Appendix A).

Limitations of the Study

The population of the study was limited to the freshman student nurses taking chemistry at Evanston Hospital School of Nursing (Evanston, Illinois) during the 1970-1971 school year.

The study was limited to the use of the following instruments: (1) the SCAT test, used to measure general intelligence; (2) the Cooperative Science Test in Chemistry and the teacher-made tests, used to measure the students' achievement in chemistry; and (3) the Scale to Measure Attitude Toward Any School Subject, used to measure the students' attitude toward chemistry. The attitude test is found in Appendix B.

Importance of the Study

This study provides additional information regarding the possibility of using individualized instruction effectively as a means of teaching a group of students of heterogeneous ability or background in the same course.

More specifically, the study provides information regarding the value of this particular method of individualized instruction in a chemistry course for freshman student nurses.

Organization of the Study

Chapter II is a review of related literature. Chapter III describes the selection of students for the groups and the methods that were used to collect the data. Chapter IV is an analysis of the data, and Chapter V gives a summary of the study and presents the conclusions of the study and recommendations for further study.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature pertinent to this study is divided into four sections. In the first section, several general articles which discuss the value of individualized instruction and techniques by which instruction can be individualized are summarized. In the second section, specific studies which compare the effects of individualized instruction to more traditional methods are discussed. In the third section, studies related to group work and group discussion are reviewed. In the fourth section, studies related to student interest are examined.

GENERAL ARTICLES

Individualized instruction in the educational process has been promoted by a number of authors. For example, Glaser has stated: "Students must be taught and must be provided with appropriate instructional materials so that they acquire increasing competence in self-directed, self-paced learning."[1]

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[1]Robert Glaser, <u>The Education of Individuals</u> (Learning Research and Development Center, University of Pittsburg, September, 1966), p. 6.

Glaser has also stated: "...a system of individualized instruction nurtures independent learning and, as a result, has the potential for producing individuals who are self-resourceful and self-appraising learners."[2] Howe, too, promoted individualized instruction when he stated: "In the last analysis, learning is something that everybody does for himself, building on his abilities and motivations. We need more individualized instruction throughout the entire educational system--ideally, each student should have his own personal track."[3]

Zahorik explained the purpose of individualized instruction when he stated: "Individualization deals with individuality. Its purpose is to recognize, enhance, and develop individuality. It is to help individual children to grow in individual ways, to become what they might become, to extend their vision and promise. The goal of individualization is to make unique persons more unique."[4] DeHaan and Doll expressed a similar idea when they said:

> Unquestionably, increased individual responsibility and commitment are needed in our society. In order that learners may become increasingly responsible and committed, their potential as individuals must be discovered, developed and released...

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[2] Ibid., p. 2.

[3] Harold Howe II, "On Libraries and Learning," Library Journal, 92:844, February 15, 1967.

[4] John A. Zahorik, "Individual Instruction and Group Instruction: A Case Study," Journal of Educational Research, 62:454, July-August, 1969.

> We...consider the chief object of individualization to be the release of potential in the individual learner, i.e., ...potential which is useful both to the learner and to the society in which he lives.[5]

The use of group discussion and group work in conjunction with individualized instruction has been promoted by several authors. Beggs, for example, sees small group discussion as a means of adapting instruction to the individual.[6] Drumheller has promoted the use of group work and group discussion for its value in satisfying the social needs of the student. He also sees group work and group discussion as opportunities to refine concepts of the individualized work.[7] He says:

> When instruction is individualized through the use of programmed texts, teaching machines, work books and the like, the social dimension of learning is reduced. The learner works his way through the maze of programmed questions at his own pace. He often finds that he is pursuing concepts as yet not familiar to his classmates, or concepts which his classmates have already explored. Some learners can thrive on such isolation, but others yearn for social contacts which will give a new dimension to their private verbal capsuled experiences.[8]

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[5]Robert F. DeHaan and Ronald C. Doll, "Individualization and Human Potential," Individualizing Instruction (Association for Supervision and Curriculum Development, National Education Association, 1964), p. 13.

[6]David W. Beggs (ed.), Team Teaching: Bold New Venture (Indianapolis: United College Press, Inc., 1964), p. 36.

[7]Sidney J. Drumheller, "Using Group Work in Developing Functional Concepts in an Individualized Instruction Setting," Journal of Secondary Education, 45:230, May, 1970.

[8]Ibid.

Drumheller has identified the following four reasons for building social interactions into any individualized instruction program:

1. Motivate and reinforce learning.
2. Provide for corrective feedback as concepts develop.
3. Provide an opportunity for open-ended responses.
4. Provide for a variety of perspectives on a concept including those related to age, region, culture, etc.[9]

The individualization of instruction is not a new concept. There have been many attempts to adapt instruction to the needs of the individual learner in American education. In 1932, The National Survey of Secondary Education showed that individual differences were being taken care of in more than 11,000 high schools by means of homogeneous grouping, special classes and "unit assignments" typical of the Dalton, Winnetka and Morrison Plans. Other techniques included problem-method and project-method teaching.[10] In 1936, Harap reported that ability grouping was the most common method of individualizing teaching in the elementary schools. Other techniques that were used at the same time included the preparation of special courses of study for retarded

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[9] Ibid., p. 237.

[10] Roy O. Billett, Provisions for Individual Differences, Marking and Promotion, National Survey of Education, Monograph 13 (Washington, D.C.: United States Government Printing Office, 1933), p. 415.

children, the development of remedial programs and the development and use of auto-instructional materials in the form of workbooks and individual assignment sheets.[11]

These initial attempts to individualize instruction through various kinds of grouping arrangements have been followed by other techniques. Team teaching as a means of individualizing instruction was developed in the Franklin School in Lexington, Massachusetts.[12] The use of teaching teams made possible a variety of grouping arrangements of students. These various grouping arrangements could be used to adjust for individual differences.

Programmed instruction has also been used as a means of individualizing instruction. Lumsdaine and Glaser have provided a review of teaching machines and programmed instruction techniques used prior to 1960.[13] The value of programmed instruction as a means of individualizing instruction is that it allows the students to work on their own and at their own pace.

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[11]Henry Harap, "Differentiation of Curriculum Practices and Instruction in Elementary Schools," The Grouping of Pupils, National Society for the Study of Education, Thirty-fifth Yearbook, Part 1 (Chicago: The Society, 1936), pp. 161-172.

[12]Robert H. Anderson, Ellis A. Hagstrom, and Wade M. Robinson, "Team Teaching in an Elementary School," School Review, 58:71-84, Spring, 1960.

[13]A. M. Lumsdaine and Robert Glaser (eds.), Teaching Machines and Programmed Learning: A Source Book, (Washington: Department of Audio-Visual Instruction, National Education Association, 1960).

Learning packages have been developed recently and are becoming a popular means of individualizing instruction. Jones, in a general article, reviewed the characteristics of three types of learning packages: Teaching Learning Units, UNIPACS, and Learning Activity Packages.[14] These are examples of written self-instructional units which guide each individual learner toward specific behavioral objectives.

The newest development in the individualization of instruction is the use of the computer to assist and manage instruction. Two general articles explain the uses of computers in education. In the first, Suppes states:

> The computer makes the individualization of instruction easier because it can be programmed to follow each student's history of learning successes and failures and to use his past performance as a basis for selecting the new problems and new concepts to which he should be exposed next.[15]

In the second article, Cooley and Glaser have outlined a general model of individualized instruction and have explained how the computer can be used to assist in the implementation of the general instructional model.[16]

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[14] Richard V. Jones, Jr., "Learning Activity Packages: An Approach to Individualized Instruction," <u>Journal of Secondary Education</u>, 43:179, April, 1968.

[15] Patrick Suppes, "The Uses of Computers in Education," <u>Scientific American</u>, 215:206-220, September, 1966.

[16] W. W. Cooley and Robert Glaser, "The Computer and Individualized Instruction," <u>Science</u>, 166:574-582, October 31, 1969.

The model contains these parts:

1. Goals of learning are specified in terms of observable student behavior.

2. Student capabilities are assessed at the beginning of the instruction.

3. Alternatives for learning that are suitable to the student are presented to him to make a choice as they are assigned.

4. Student performance is continuously assessed during the learning.

5. Instruction proceeds as a function of the relationship between measures of student performance, available instructional alternatives, and criteria of competence.

6. As instruction proceeds, data are generated for monitoring and improving the instructional system.[17]

SPECIFIC STUDIES

Dutton reported a study in which he used programmed materials to individualize instruction for fourth grade students.[18] He found that when students were taught the concepts of sound, heat, and light by programed materials they had a significantly greater achievement when compared with students taught in the conventional way. Dutton admitted the possible effect of the teachers' enthusiasm for the programmed materials in the experimental groups.

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[17] Ibid., p. 575.

[18] Sherman Sumpter Dutton, "An Experimental Study in the Programming of Science Instruction for the Fourth Grade," Abstract: Dissertation Abstracts, 24:2382, December, 1963.

Two studies have been reported which attempted to evaluate the effects of computer assisted instruction (CAI) on student achievement. The first of these was done at the Brentwood School in California.[19] Half of the first-grade students taking part in this experiment received reading instruction by means of CAI. The other half of the students received traditional instruction in reading. To reduce possible Hawthorne effects, the control group received math instruction by CAI. The results of the study showed that the students in the experimental group performed significantly better on all posttest measures but the comprehension subtest of the California Achievement Test. Students were not significantly different at the beginning of the experiment on any pretest measures. It should be noted that the students taking part in this experiment were below average in general academic ability, having an average I.Q. of 89.

The second study involving CAI was reported by Castleberry, Montague, and Lagowski.[20] The authors developed and evaluated computer programs for use in an introductory college chemistry course. The programs included tutorial-drill modules and experiment-simulation modules. The achievement of a group of students who used these modules

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[19] R. C. Atkinson, American Psychologist, 23:225, 1968.

[20] S. J. Castleberry, E. J. Montague, and J. J. Lagowski, "Computer-Based Teaching Techniques in General Chemistry," Journal of Research in Science Teaching, 7:197-208, 1970.

as a supplement to their regular chemistry instruction was compared to that of a control group who received only the regular instruction. Both the treatment and control groups were chosen from a group of students who had volunteered for the computer assisted instruction. The results of the study showed that the CAI programs had a significant effect on achievement. The authors warned, however, that several confounding factors may have influenced the results. These factors include some low test reliability and questions of validity. It does appear, though, that at the level of significance achieved (.003), the modules were a useful study aid for students taking beginning college chemistry.

Grant individualized instruction by allowing students to help in the planning of goals and procedures in the classroom.[21] Students worked at their own rates without being held back or pushed ahead to keep up. The achievement of students in the individualized group was compared to that of a traditional group and an intermediate group which had characteristics of both. Test results did not show differences large enough to reject the hypothesis of no differences among the groups.

O'Toole attempted to determine the comparative effects of an individualized instruction approach and a

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[21] Jettye Fern Grant, "A Longitudinal Program of Individualized Instruction in Grades 4, 5, and 6," Abstract: Dissertation Abstracts, 25:2882, September, 1964.

teacher centered approach on the achievement of problem-solving skills, science interest, and self concept.[22] Lessons for the individualized group were adapted from Science--A Process Approach. Three groups of fifth grade pupils were used in the study. The results showed no differences between the individualized instruction group and two teacher-centered groups on measures of science interest, knowledge of content, or self concept. Significant increases at the .01 level of significance were reported for the treatment group on measures of selected problem solving abilities and the ability to identify hypotheses.

Learning packages were used in an individualized program of study for Junior High School science, math, language arts, and social studies.[23] Achievement of students using the individualized approach was compared with that of students being taught in a traditional way. Students proceeded through self-instructional learning packages at their own rates, using a variety of materials that were placed at their disposal. Significantly greater achievement was reported by Sinks in math, social studies, and writing,

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[22] Raymond Joseph O'Toole, "A Study to Determine Whether Fifth Grade Children can Learn Certain Selected Problem Solving Abilities Through Individualized Instruction. (Research Study Number 1)," Abstract: Dissertation Abstracts, 27:3781, May, 1967.

[23] Thomas A. Sinks, "How Individualized Instruction in Junior High School Science, Mathematics, Language Arts, and Social Studies Affects Student Achievement," Illinois School Research, 5:5-12, May, 1969.

but not in science. The author suggests that this may have been due to the fact that the science instruction lasted only one semester instead of two semesters as the others did. Not enough time passed for significant differences to appear.

Another study related to self-instructional units was reported by Bass.[24] He developed a series of self-instructional units for use in physical science courses according to psychological sequences identified by Piaget. Each unit was meant to lead a student from his actions with physical equipment to the formulation of a mathematical equation. The units were evaluated by determining the extent to which ninth grade physical science students attained the stated objectives. No comparison group was used in this study. It was concluded, however, that the evaluation as performed indicated that the units were successful in assisting students to attain the objectives.

Richard and Sund reported a study in which several aspects of individualized instruction were investigated.[25] First, they determined the feasibility of the continuous progress plan versus the individualized unit approach to individualized instruction. ("The continuous progress plan

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[24] Joel Eugene Bass, "The Development and Evaluation of Self-Instructional Physical Science Materials Based on Piaget's Analysis of the Growth of Logical Thinking," Abstract: Dissertation Abstracts, 29:3515A, April, 1969.

[25] Paul Richard and Robert Sund, "Individualized Instruction in Biology," American Biology Teacher, 31:252-256, April, 1969.

allows a student to progress through course work at his own rate. When a student finishes the reading of a unit of work and achieves well on an examination he then proceeds to the next section of the course... Under the individualized unit plan, the student also is encouraged to go through the text and laboratory material at his own rate. However, once the student finishes the required material he does not progress to the next unit but does supplemental laboratory activities or other enrichments. He has opportunities to study in depth the topic covered in the unit."[26]) Second, the authors determined the feasibility of using three forms of the student syllabus, one for each of three levels of student ability. Third, the teaching method that was preferred was compared to the traditional method. The study itself had three phases. Two groups of high school biology students were matched according to the Differential Aptitude test scores, science achievement, and I.Q. scores. During the first phase of the study, which lasted eight weeks, all students received one of three forms of the student syllabus and followed the continuous progress plan. After eight weeks both the continuous progress plan and the three forms of the syllabus were rejected. Continuous progress was difficult to handle in a biology class in which many live specimens were used. The three forms of the student syllabus were

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[26]*Ibid.*, p. 253.

rejected in favor of just one form because the students did not like to receive the labels that the forms of the syllabus implied. During the second phase of the study both the experimental and control groups received instruction by means of a single-track syllabus according to the individualized unit plan. This phase also lasted eight weeks and, at the end of this time, the experimental and control groups were compared on achievement measures. No significant differences existed between the two groups at this time. During the third phase of the study, which also lasted eight weeks, the experimental group continued to receive instruction by means of the student syllabus. The control group was taught by conventional means. At the end of this phase no significant differences in achievement appeared between the two groups. However, the students generally preferred the individualized approach.

In another study, Morris compared traditional high school instruction to an individualized approach characterized by team teaching, continuous progress programs, independent study, modular scheduling, and small group instruction.[27] Data was collected over a five year period beginning the year before the introduction of individualized instruction and continuing throughout its development. Of thirteen comparisons

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[27]Julian Clair Morris, "A Descriptive Analysis and Evaluation of an Integrated Program of Individualized Instruction in Cedar City High School," Abstract: Dissertation Abstracts, 29:2937A.

of attitudes and achievement between the two methods, nine showed no significant differences, three favored conventional instruction, and one favored the individualized approach.

Shavelson and Munger reported a study in which they attempted to determine if an individualized self-paced instruction approach combined with small group discussion would be more effective than a conventional lecture approach in teaching basic biochemistry to high school biology students.[28] The lectures and discussions for the traditional group were mediated by means of a teacher-slide presentation, and the experimental group's lectures were mediated by tape-slide presentation. The study lasted for two weeks. Results of the study showed that students using the individualized approach achieved more in less time than the traditionally taught students.

STUDIES RELATED TO GROUP WORK AND GROUP DISCUSSION

Schindler, after giving one hundred eighty elementary school pupils the opportunity to complete a project as an individual and as a group, found that a significantly larger number preferred to work alone after having had both experiences.[29] She also found that the quality of the group projects as evaluated by a committee of eight experienced

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[28] R. J. Shavelson and M. R. Munger, "Individualized Instruction: A Systems Approach," The Journal of Educational Research, 63:263-268, February, 1970.

[29] Arlene Katharine Schindler, "A Study of the Attitudes of Fifth Grade Children Toward Group and Individual Work," Abstract: Dissertation Abstracts, 25:3332, December 1964.

fifth grade teachers was significantly greater than that of the individual projects.

Spraker found no significant differences in the creativity scores of seventh grade mathematics pupils who studied alone and in groups of six to eight pupils.[30] Students were randomly assigned to treatment groups and creativity scores were adjusted for I.Q. and arithmetic achievement.

In an experiment involving the use of study teams in college level general psychology, Gore found that students who learned in teams of three or four achieved more than students taught in a traditional way.[31] The teams performed the activities on a job sheet, while the control group attended lectures. The control and experimental groups were equated on the basis of college ability tests and previous quarter grades before the experiment began.

The use of study-teams was also reported by Kernan.[32] He found that academic growth was not significantly better for groups consisting of three to eight members. He did, however, feel that the use of study-teams had several advantages: the class was more interesting, there was a

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[30] Harold Stephen Spraker, "A Study of the Comparative Emergence of Creative Intellectual Behavior During the Process of Group and Individual Study of Mathematics," Abstract: Dissertation Abstracts, 21: 2199, February, 1961.

[31] Alfonso E. Gore, "Individualized Instruction Through Team Learning in a College Course in General Psychology," Abstract: Dissertation Abstracts, 23:1273, October, 1962.

[32] Thomas F. Kernan, "Student Study-Teams in the Tenafly Junior High School--A Case History," (Doctoral Dissertation, Columbia University, 1966).

better opportunity for social growth, more individual attention could be given, missed work was more easily made up, and students could often explain the lessons in easier to understand terms. The weaknesses of the study-teams included poor group behavior and failure to stick to the subject.

Pearl discovered that when seventh and eighth grade underachievers in mathematics were grouped in teams of three members, they achieved significantly more during the year than students who were not grouped.[33] He found no significant changes in the attitudes of the two groups at the end of the year.

STUDIES RELATED TO STUDENT INTEREST

Walberg has stated that participation in science activities may be a better indicator of student interest than expressed interest, since time and effort is required of the student.[34] Related to this, Cooley and Reed have proposed a seventy-item science interest survey which uses statements about students' activities related to science rather than statements about interest in science.[35]

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[33] Andrew W. Pearl, "A Study of the Effects on Students' Achievement and Attitudes When They Work in Academic Teams of Three Members" (Doctoral Dissertation, Cornell University, 1967).

[34] Herbert J. Walberg, "Dimensions of Scientific Interests in Boys and Girls Studying Physics," Science Education, 51:111-116, March, 1967.

[35] W. W. Cooley and H. B. Reed, "The Measurement of Science Interests: An Operational and Multidimensional Approach," Science Education, 45:320-326, 1961.

An interesting study was reported by Scriven, Harrison, and Scriven in which they tried to determine the effect of an individual progression program on students' attitudes when compared with a traditional program.[36] The Flander's Michigan Student Questionnaire was used to measure attitude toward school. The results showed that the control group had a significant decrease in positive attitude during the course of the year while there was no significant difference in pretest and posttest attitude score for the experimental group. The decrease in attitudes using this scale has been reported also by Flanders.[37] When comparing the two groups, the authors conclude that the individualized approach may be a factor influencing positive attitudes toward school, although the data is inconclusive.

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[36] Georgia H. Scriven, Alton Harrison, Jr., and Eldon G. Scriven, "A Study of Student Attitude Changes Related to Individual Progression," Illinois School Research, 6:16-21, May, 1970.

[37] N. A. Flanders, "Helping Teachers Change Their Behavior," Terminal Report of NDEA Title VII Project, 1963.

CHAPTER III

METHODS OF ASSIGNING STUDENTS AND COLLECTING DATA

The purpose of this chapter is to explain: (1) the methods of assigning students to the various groups, and (2) the data that was collected and the methods that were used to collect the data.

ASSIGNMENT OF STUDENTS

Initially, sixty-nine students were to take part in the experiment. These students comprised the total population of freshman student nurses at Evanston Hospital School of Nursing. The names of the students were listed alphabetically and numbered from one to sixty-nine. A table of random numbers was then used to select thirty-four students for the treatment group. The remaining thirty-five students were assigned to the control group. From the time of the initial assignment of students until the time the experiment ended, six students resigned from school. Due to these resignations, complete data was collected on thirty-three members of the original control group and thirty members of the original treatment group.

When the chemistry course began, eleven students from the treatment group and thirteen students from the control group had been in a surgical nursing course for the previous six weeks. The remaining students in the treatment and control groups had been in a medical nursing course for the previous six weeks. Three weeks after the experiment began, the students who had had surgical nursing started the medical nursing course, and vice versa. Therefore, the order in which students in both the treatment and control groups took medical and surgical nursing varied. Since it was possible that the order in which students took medical and surgical nursing might have an effect on achievement in chemistry, the effect of the order of taking the two nursing courses was tested.

Although students were assigned randomly to the treatment and control groups, it was not possible to assign students to the medical and surgical groups randomly. However, the number of students in the treatment group who had surgical nursing first (eleven) was approximately equal to the number of students in the control group who had surgical nursing first (thirteen). Also, the number of students in the treatment group who had medical nursing first (nineteen) was approximately equal to the number of students in the control group who had medical nursing first (twenty). It was thus possible to test for the effect of the order of the nursing courses by using the analysis of covariance technique. (See Chapter IV Analysis of Data)

The grouping of students at the start of the experiment appears in Figure 1. As seen in this figure, another grouping arrangement existed as well. Groups I and II comprised the control group and Groups III and IV comprised the treatment group. This grouping also existed for scheduling in other classes. The thirty-three students in Groups I and II met together for two one-hour lectures each week. The first lecture was on Monday morning from eleven o'clock until noon. The second lecture was on Tuesday afternoon from one o'clock until two o'clock. For scheduling reasons, half of the treatment group met at one time and the other half of the class met at another time. Students in Group III met on Tuesday morning from nine o'clock until eleven o'clock and the students in Group IV met on Wednesday morning from nine o'clock until eleven o'clock. Data from Groups III and IV was treated together.

	Control Group			Treatment Group		
	Group I	Group II	Total	Group III	Group IV	Total
Medical Nursing First	11	9	20	9	10	19
Surgical Nursing First	6	7	13	7	4	11
Totals	17	16	33	16	14	30

Figure 1. Number of Students in Each Group

COLLECTION OF DATA

Data was collected which related to the students' achievement in chemistry and the students' attitude toward chemistry. During the week prior to the start of the experiment, the students' knowledge of chemistry was measured by means of the Cooperative Science Test in Chemistry, and their attitude toward chemistry was measured by means of the Scale to Measure Attitude Toward Any School Subject.

When the students took the chemistry pretest, they were told that they would not be graded on the test. The instructor told them that it would be helpful for him to know how much they already knew about chemistry so he would know what to teach. They were asked to do as well as they could on the test to give the instructor accurate information about their knowledge.

Before taking the attitude test, students were again told that the results of the test would have no effect on their grade. They were asked to answer each question as honestly as possible because their instructor was interested in finding out how student nurses felt about chemistry. The same test of attitudes was given again during the next to the last week of the course.

As another indication of attitude toward chemistry, students were required to hand in a record of the amount of time they spent studying chemistry out of class each week. Forms were provided for this purpose and collected weekly.

A copy of this form appears in Appendix C. Students were told that the record of their study time would not influence their grade or their instructor's opinion of them. They were told that the information might be valuable to have in certain situations when a student was having difficulty in the course. Students seemed to be very honest in reporting their study time. They were not even afraid to report zero time studying when they did not study.

One more piece of information was obtained during the phase of the study that related to student attitude toward chemistry. Attendance at four films that related to the topic being studied at the time was used as an indication of student interest. Since there was no single time during the week that gave all students an equivalent opportunity to see the films, all films were shown at four different times. The times that were chosen provided each student with an equal opportunity to see the films.

Achievement in chemistry was measured by means of three teacher-made tests which were given during the course. Students in both the treatment and control groups took the tests at the same time. The tests were composed of questions which were carefully written from the statements of behavioral objectives which all students received weekly.

The students were not aware of the fact that their instructor was using the information gained from this experiment for his doctoral study. At the beginning of the experiment, when the method of instruction had been explained to the appropriate group, the instructor told each group that he was going to try out some new things in chemistry this year with both classes. He also told them that the two classes would not be doing everything in exactly the same way, but that they would learn the same things. They were also told that their grade would not be affected by the method of instruction that they received. Their grade would be determined in relation to the students who received the same method of instruction.

CHAPTER IV

ANALYSIS OF DATA

The analysis of the data is in two main parts. First, it was determined whether or not the order in which students had medical and surgical nursing had different effects on achievement and attitude in chemistry. Second, it was determined what effect the treatment had on achievement in and attitude toward chemistry by comparing students in the treatment group with students in a control group.

COMPARISON OF MEDICAL AND SURGICAL GROUPS ON ACHIEVEMENT AND ATTITUDE MEASURES

In this section the data is analyzed to determine the initial equality of the medical and surgical groups, and the effects of the order of having medical and surgical nursing on achievement in and attitude toward chemistry.

Test of the Initial Equality of the Medical and Surgical Groups

The initial equality of these two groups was determined by using five criteria. The criteria that were used were: (1) SCAT verbal score, (2) SCAT quantitative score, (3) first semester grade point average, (4) Cooperative Test in

Chemistry pretest score, and (5) the pretest score on the Scale to Measure Attitudes Toward Any School Subject. The SCAT scores and grade point averages were taken from the students' records and the chemistry pretest scores and the attitude pretest scores were obtained during the first week of the course. A summary of this initial data appears in Table I.

Analysis of variance was used to compare the means of each of the pretest scores for the two groups. First, the assumption of homogeneity of variance was tested by using Hartley's F_{max} statistic. The results of this analysis which appear in Appendix E indicate that the variances are homogenous for all five measures. After this was done, the means of the initial data were compared by using the program, MANOVA--Multivariate Analysis of Variance, from the Northwestern University Vogelback Computing Center. The level of significance for this test was chosen to be 0.05. The results of this analysis appear in Table II. The results indicate that the students who had medical nursing first differed significantly from the students who had surgical nursing first on the SCAT verbal score and on the Chemistry pretest. In addition, the F ratio from the SCAT quantitative score is so near to the critical value that the groups were considered to be different on this measure as well. These pretest measures on which the two groups differed significantly were examined for their suitability as covariates in the

TABLE I

SUMMARY OF INITIAL DATA FOR MEDICAL AND SURGICAL NURSING STUDENTS

	SCAT Verbal	SCAT Quantitative	GPA	Chemistry Pretest	Attitude Pretest
			Medical Nursing First		
n	39	39	39	39	39
$\bar{x}$	38.667	37.401	2.581	48.282	6.641
S^2	24.334	30.305	0.461	49.210	3.386
			Surgical Nursing First		
n	24	24	24	24	24
$\bar{x}$	35.583	34.708	2.524	43.458	6.683
S^2	15.817	21.959	0.321	66.602	3.045

n = number of students

$\bar{x}$ = sample mean

S^2 = sample variance

TABLE II

TEST FOR EQUALITY OF SAMPLE MEANS OF INITIAL DATA
FOR MEDICAL AND SURGICAL GROUPS

Variable	F(1,61)	p
SCAT Verbal	6.867*	< 0.05
SCAT Quantitative	3.994*	0.05
Grade Point Average	0.118	> 0.05
Chemistry Pretest	6.199*	< 0.05
Attitude Pretest	0.008	> 0.05

Critical Region: $F(1,61)_{.05} > 4.00$

comparison of the achievement of the two groups. This topic is discussed in the next section.

Test of the Achievement of the Medical and Surgical Groups

The achievement of the medical and surgical groups was compared on three teacher-prepared tests of subject matter knowledge. The first two tests each contained fifty multiple choice questions. The tests were divided into two parts. The first part contained thirty-two questions which covered the material in Part 1 of the learning guide. The second part contained eighteen questions which covered the material taught in Part 2 of the learning guide. All questions were written from the lists of objectives that the students received each week.

The third test was the final examination and it contained one hundred multiple choice questions. The test was divided into two halves, with each half containing fifty questions. The first half of the final examination covered material taught in the last third of the course, and the second half of the final examination covered material taught in the first two-thirds of the course. The fifty questions in this second half of the test were chosen randomly from each of the parts of the first two tests. Each fifty question half of the test was separated into two parts in exactly the same way as the first two achievement tests. The three achievement tests contained a total of eight parts and the data from these tests appears in Table III. The achievement tests appear in Appendix D.

Analysis of covariance was chosen to compare the means of the achievement test scores for the two groups. This achievement data was first analyzed to determine if the variance of each test was homogeneous between the two groups. The Hartley F_{max} statistic was used to test for homogeneity of variance at the 0.05 level of significance. The results, which appear in Appendix E, show that the variance is homogeneous for all but two of the achievement measures. These are both parts of the second achievement test.

Next, since the medical and surgical groups differed with respect to the SCAT scores and the Chemistry pretest scores, these measures were examined to determine their possible use as covariates in the comparison of the achievement of the two groups. First semester grade point average was not examined as a possible covariate since the two groups did not differ with respect to this variable. The two assumptions which had to be met by each of these were (1) that the regression of each achievement variable on the pretest measure was significantly greater than zero, and (2) that the regression of each achievement variable on the pretest measure was homogeneous between the two groups. The significance of overall regression was tested by the MANOVA program and the homogeneity of regression

TABLE III

SUMMARY OF ACHIEVEMENT DATA FOR MEDICAL AND SURGICAL NURSING STUDENTS

	Medical Group			Surgical Group		
Variable	n	$\bar{x}$	s^2	n	$\bar{x}$	s^2
ACH Test I - Part 1	39	28.000	10.844	24	27.208	13.476
ACH Test I - Part 2	39	13.744	7.879	24	12.708	8.738
ACH Test II - Part 1	39	19.692	33.698	24	19.208	16.959
ACH Test II - Part 2	39	6.821	8.049	24	5.958	3.779
Final Exam						
Section A - Part 1	39	21.179	23.571	24	20.000	15.476
Section A - Part 2	39	10.846	10.394	24	10.625	7.986
Section B - Part 1	39	22.974	20.548	24	20.833	15.713
Section B - Part 2	39	9.103	9.199	24	8.333	5.276

n = number of students

$\bar{x}$ = sample mean

s^2 = sample variance

hypothesis was tested by the statistic which appears below. The results of these tests appear in Appendix E.

$$F = \frac{S_3/k-1}{S_1/N-2k} \qquad S_1 = \sum y_w^2 - \sum_1^k \frac{\left(\sum_1^n xy_k\right)^2}{\sum_1^n x_k^2}$$

$$S_3 = S_2 - S_1 \qquad S_2 = \sum y_w^2 - \frac{\left(\sum xy_w\right)^2}{\sum x_w^2}$$

Based on the results of the test of the assumptions, two analyses of covariance were performed on the achievement test data. In the first, the Chemistry pretest was used as a covariate for all of the achievement test scores. In the second, the SCAT quantitative score was added as a covariate in the cases where it met the necessary assumptions. The MANOVA program was used to analyze the data and the level of significance was chosen to be 0.05.

The results of the first analysis appear in Table IV. The two groups did not differ significantly on any of the achievement test measures when the Chemistry pretest was used as a covariate to adjust for the initial differences that existed in the two groups at the beginning of the experiment. The results of the second analysis appear in Table V. This analysis indicates that no significant differences existed in the achievement of these two groups when initial differences in chemistry knowledge and quantitative ability were corrected by using the SCAT quantitative score and the Chemistry pretest as covariates.

TABLE IV

ANALYSIS OF COVARIANCE OF ACHIEVEMENT TEST MEANS FOR MEDICAL AND SURGICAL NURSING STUDENTS USING CHEM PRETEST AS A COVARIATE

VARIABLE	F(1,60)	p
ACH Test I - Part 1	0.071	>0.05
ACH Test I - Part 2	0.071	>0.05
ACH Test II - Part 1	0.234	>0.05
ACH Test II - Part 2	0.183	>0.05
Final Exam		
Section A - Part 1	0.087	>0.05
Section A - Part 2	0.386	>0.05
Section B - Part 1	1.608	>0.05
Section B - Part 2	0.021	>0.05

Critical Region: $F(1,60)_{.05} > 4.00$

TABLE V

ANALYSIS OF COVARIANCE OF ACHIEVEMENT TEST MEANS FOR MEDICAL AND SURGICAL NURSING STUDENTS USING CHEM PRETEST AND SCAT QUANTITATIVE AS COVARIATES

VARIABLE	F(1,59)	p
ACH Test II - Part 2	0.044	>0.05
Final Exam		
Section A - Part 2	0.700	>0.05
Section B - Part 2	0.054	>0.05

Critical Region: $F(1,59)_{.05} > 4.01$

Although the students who had medical or surgical nursing first did not differ significantly on any measure of achievement, the medical group scored higher than the surgical group on all of the eight achievement measures. In addition, the variance of the medical group's scores was higher on six of the eight parts of the achievement tests.

The differences are consistent with differences which existed in the groups at the start of the experiment. In the pretest data, for example, the medical group scored significantly higher on three of five measures, and the variance of their scores was higher in four of five cases. The variance was not significantly higher, however, for any of these measures. In spite of the non-significance of differences between the variance of the two groups, the medical group appeared to be consistently less homogeneous than the surgical group. For this reason some additional evidence of this was sought and is presented here without statistical treatment. This data appears in Tables VI - X.

To determine whether or not students who took surgical nursing first formed a more homogeneous group than the students who took medical nursing first, five additional pieces of information were obtained for each student. These are: (1) whether or not the student came to nursing school directly from high school, (2) rank in high school class, (3) type of high school attended, (4) ACT natural science score, and (5) high school chemistry grade.

The results in Table VI indicate that on the first of these, the students in the surgical group appear to be somewhat more homogeneous. Of the students in the surgical group, seventy-eight percent came to nursing school directly from high school while only sixty-one percent of the students in the medical group came directly from high school. A larger percentage of the students in the medical group had various work or college experience first.

Information about the students' rank in their high school class found in Table VII indicates again that the students in the surgical group form a more homogenous group. Of the students in the surgical group, sixty-two percent are ranked in the second quartile as compared to forty-five percent of the students in the medical group who are ranked in this quartile. Also, smaller percentages of surgical students are at the higher and lower rankings.

Information on the type of high school attended does not seem to show any substantial differences between the two groups as seen in Table VIII. The data from the natural science score on the ACT found in Table IX also fails to demonstrate that one group is more homogeneous than the other. While fewer of the surgical students received high scores, a greater number received low scores. This makes the mean score lower, but it does not indicate that the group is more or less homogeneous.

Finally, the high school chemistry grade data found in Table X again indicates that the students who took surgical

TABLE VI

PRE-NURSING SCHOOL EXPERIENCE OF STUDENTS
IN MEDICAL AND SURGICAL GROUPS

	Medical Group	Surgical Group
Came to Nursing School Directly From High School	61.5%	78.0%
Had College or Work Experience First	38.5%	22.0%

TABLE VII

RANK IN HIGH SCHOOL CLASS OF STUDENTS
IN MEDICAL AND SURGICAL GROUPS

Rank	Medical Group	Surgical Group
Top Decile	15.8%	4.2%
Top Quartile	23.7%	20.8%
Second Quartile	44.7%	62.5%
Lower Half	15.8%	12.5%

TABLE VIII

TYPE OF HIGH SCHOOL ATTENDED BY STUDENTS IN MEDICAL AND SURGICAL GROUPS

	Medical Group	Surgical Group
City Public	5.3%	4.2%
Suburban Public	52.6%	45.6%
Parochial	31.6%	37.4%
Other	10.5%	12.5%

TABLE IX

ACT NATURAL SCIENCE SCORE OF STUDENTS IN MEDICAL AND SURGICAL GROUPS

Score	Medical Group	Surgical Group
11-15	0.0%	21.1%
16-20	34.3%	31.6%
21-25	28.6%	36.9%
26-30	31.5%	10.5%
31-35	5.7%	0.0%

TABLE X

HIGH SCHOOL CHEMISTRY GRADE OF STUDENTS IN MEDICAL AND SURGICAL GROUPS

Grade	Medical Group	Surgical Group
< C	13.1%	13.6%
C to C+	50.0%	72.8%
B to B+	31.6%	13.6%
> B+	5.3%	0.0%

nursing first form a more homogeneous group. Of the students in the surgical group, seventy-three percent had a C to C+ average in high school chemistry, while the largest number in any one category for the medical group was fifty percent in the C to C+ category.

This data, plus the pretest data that was analyzed statistically, indicates that the medical group has a higher ability than the surgical group and is less homogeneous. This fact is most likely due to a sampling technique which was not random. Students were assigned to the medical and surgical nursing classes by their nursing instructors on an alphabetical basis.

Comparison of Attitudes

The medical and surgical groups were compared on three attitude measures at the end of the experiment. One of these was the average number of hours per week that students in each group spent studying chemistry. A second was the number of optional films that were viewed by each student in the two groups. A third was the Scale to Measure Attitude Toward Any School Subject which had previously been used as a pretest.

The written attitude pretest was the only criterion used to determine the initial equality of the attitude of the two groups. The results of this pretest indicate that the medical and surgical groups did not differ significantly in their attitude toward chemistry at the beginning of the experiment. This pretest data appears in Table XI along with the posttest attitude data.

The means of the three attitude measures were compared by using the analysis of variance technique from the MANOVA program. The level of significance was again chosen to be 0.05 and the results of this analysis appear in Table XI. The results indicate that there was no significant difference in the attitude of the two groups as measured by these three tests.

In summary, all of the statistical tests that were performed indicate that the order in which student nurses took medical and surgical nursing had no effect on either their achievement in chemistry or their attitude toward chemistry.

COMPARISON OF CONTROL AND TREATMENT GROUPS ON ACHIEVEMENT AND ATTITUDE MEASURES

In this section the data is analyzed to determine the initial equality of the control and treatment groups, and the effects of the treatment on achievement in and attitude toward chemistry.

Test of the Initial Equality of the Control and Treatment Groups

The initial equality of the control and treatment groups was determined by using the same five criteria that were used in Part I of this chapter. The criteria that were used were: (1) SCAT verbal score, (2) SCAT quantitative

TABLE XI

SUMMARY OF ATTITUDE DATA FOR
MEDICAL AND SURGICAL GROUPS

Variable	Group	n	$\bar{x}$	s^2	Comparison of Means (F 1,61)
Attitude Pretest	Medical	39	6.641	3.386	0.008
	Surgical	24	6.683	3.045	
Attitude Posttest	Medical	39	5.762	4.558	0.135
	Surgical	24	5.958	3.801	
Film Attendance	Medical	39	1.359	1.553	1.204
	Surgical	24	1.792	3.565	
Weekly Study Time	Medical	39	2.185	1.053	1.743
	Surgical	24	2.525	0.869	

Critical Region: $F(1,61)_{.05} > 4.00$

score, (3) first semester grade point average, (4) Cooperative Test in Chemistry pretest score, and (5) the score on the Scale to Measure Attitudes Toward Any School Subject which was given as a pretest. A summary of this data appears in Table XII.

The data was first tested for homogeneity of variance by using Hartley's F_{max} statistic. The results of this test appear in Appendix E. The variance of all initial tests was homogeneous except for the variance between the two groups on the attitude pretest.

The data was then tested to determine if a significant difference existed in the means of the initial data from the two groups. The MANOVA program was used to analyze this data. The results of the analysis appear in Table XIII. These results indicate that the control and treatment groups did not differ significantly on any of the pretest measures. However, large enough differences existed in the attitude pretest scores to use the test as a covariate in the analysis of the posttest attitude scores. In all other respects, the groups were considered to be equivalent at the start of the experiment.

Tests of Achievement

After determining the initial equality of the two groups, the control and treatment groups were compared on measures of achievement and attitude. The findings from the achievement data are presented first. A summary of this

TABLE XII

SUMMARY OF INITIAL DATA FOR STUDENTS
IN CONTROL AND TREATMENT GROUPS

	SCAT Verbal	SCAT Quantitative	GPA	Chemistry Pretest	Attitude Pretest
			Control Group		
n	33	33	33	33	33
$\bar{x}$	37.273	36.545	2.530	46.515	6.255
s^2	21.455	32.501	0.326	51.323	4.293
			Treatment Group		
n	30	30	30	30	30
$\bar{x}$	37.733	36.200	2.592	46.367	7.100
s^2	25.513	24.920	0.457	72.590	1.724

n = number of students

$\bar{x}$ = sample mean

s^2 = sample variance

TABLE XIII

TEST FOR EQUALITY OF SAMPLE MEANS OF INITIAL DATA FOR CONTROL AND TREATMENT GROUPS

Variable	F(1,61)	p
SCAT Verbal	0.163	>0.05
SCAT Quantitative	0.065	>0.05
First Semester GPA	0.147	>0.05
Chemistry Pretest	0.006	>0.05
Attitude Pretest	3.656	>0.05

Critical Region: $F(1,61)_{.05} > 4.00$

data appears in Table XIV. The findings from the attitude data appear in the next section of this chapter.

The achievement data was first tested for homogeneity of variance at the 0.05 level of significance. The results, found in Appendix E, indicate that the assumption of homogeneity of variance is met in each case.

Next, the means of the achievement tests for the two groups were compared using analysis of variance. The 0.05 level of significance was again chosen. The results of this analysis appear in Table XV and indicate that the control and treatment groups did not differ significantly on any of the achievement tests.

In the analysis of the achievement data, as it was performed, the individual achievement measures were tested as separate variables. This was done because the tests were given at different times and were used to test different subject matter. However, the correlation among the separate achievement measures is quite high. This indicates that the individual tests are measuring much the same thing. The correlations of all dependent variables appears in Appendix F.

Because of this high correlation among the achievement measures, it is possible to consider them as a single variable. This was done by using two different techniques. In the first, all achievement scores were added together to give a total achievement score for each student. Analysis of variance was then used to determine whether or not the

TABLE XIV

SUMMARY OF ACHIEVEMENT TEST DATA FOR CONTROL AND TREATMENT GROUPS

	Control			Treatment		
Variable	n	$\bar{x}$	s^2	n	$\bar{x}$	s^2
ACH Test I - Part 1	33	27.576	12.688	30	27.833	11.176
ACH Test I - Part 2	33	13.485	7.447	30	13.200	9.543
ACH Test II - Part 1	33	19.182	23.088	30	19.867	31.979
ACH Test II - Part 2	33	6.333	4.605	30	6.667	8.779
Final Exam						
Section A - Part 1	33	20.212	18.046	30	21.300	23.319
Section A - Part 2	33	10.394	9.060	30	11.167	9.660
Section B - Part 1	33	21.545	20.376	30	22.833	18.353
Section B - Part 2	33	8.394	6.933	30	9.267	8.480
Total Achievement Score	33	127.121	438.065	30	132.133	603.341

n = sample size

$\bar{x}$ = sample mean

s^2 = sample variance

TABLE XV

TEST FOR EQUALITY OF SAMPLE MEANS OF ACHIEVEMENT TEST DATA FOR CONTROL AND TREATMENT GROUPS

Variable	F(1,61)	p
ACH Test I - Part 1	0.087	>0.05
ACH Test I - Part 2	0.151	>0.05
ACH Test II - Part 1	0.270	>0.05
ACH Test II - Part 2	0.265	>0.05
Final Exam		
Section A - Part 1	0.905	>0.05
Section A - Part 2	1.004	>0.05
Section B - Part 1	1.342	>0.05
Section B - Part 2	1.561	>0.05
Total Achievement Score	0.764	>0.05

Critical Region: $F(1,61)_{.05} > 4.00$

two groups differed with respect to this new variable. The results, which appear in Table XV indicate that the groups do not differ with respect to this total achievement score.

Next, a multivariate technique was used to analyze the achievement measures. In this technique, the Wilks Lambda Criterion is used, and a single F ratio is generated to compare a group of achievement measures. The results of this analysis appear in Table XVI. The results indicate that when the achievement data is treated in this way, no significant differences appear between the treatment and control groups.

In summary, achievement in chemistry did not differ significantly under the methods of instruction as measured by the tests that were used. This was found to be true when achievement data was considered separately or combined as one variable.

In spite of this finding, there is one statistically non-significant trend which is worth noting. Although the treatment group did not score significantly higher than the control group on any of the achievement tests, the difference between the scores of the groups became greater as time went on. When the point difference between the two groups is plotted versus time, a linear relationship appears. This trend can be seen in Table XVII and Figure 2.

If this trend were to continue, the difference between the groups would soon become statistically

TABLE XVI

MULTIVARIATE ANALYSIS OF ACHIEVEMENT TEST DATA FOR CONTROL AND TREATMENT GROUPS USING WILKS LAMBDA CRITERION

Variable	F(6,56)	p
ACH Test I - Part 1 ACH Test I - Part 2 ACH Test II - Part 1 ACH Test II - Part 2 Final Exam - Part 1 Final Exam - Part 2	0.761	>0.05

Critical Region: $F(6,56)_{.05} > 2.32$

TABLE XVII

POINT DIFFERENCE ON ACHIEVEMENT TESTS VERSUS TIME FOR CONTROL AND TREATMENT GROUPS

Time	Point Difference per 50 questions (Treatment Score minus Control Score)
4 weeks	-0.028
8 weeks	+1.019
12 weeks	+2.011

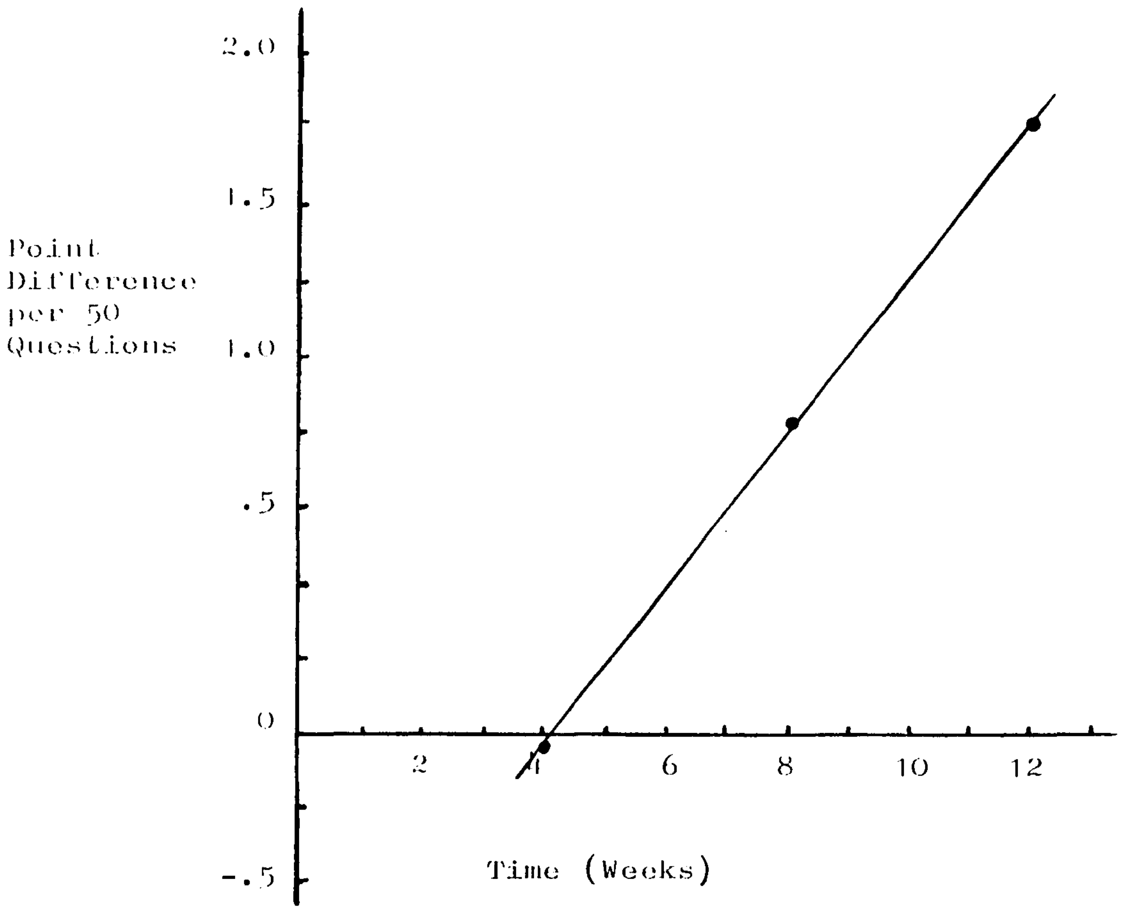

Figure 2. Difference in Achievement for Control and Treatment Groups Plotted Versus Time.

significant. It is reasonable to assume that the experimental group needed some time to get used to the new method of instruction and could perform at its best only after this time. At this point we can only speculate concerning whether or not the treatment group had reached its highest level and whether or not the difference between the groups would continue to increase over time.

Comparison of Attitudes

The control and treatment groups were compared on the same three attitude measures that were used to compare the attitude of the medical and surgical groups. The three were: (1) hours per week that students reported that they spent studying chemistry, (2) number of optional films viewed, and (3) the Scale to Measure Attitude Toward Any School Subject used as a posttest.

The Scale to Measure Attitude Toward Any School Subject had previously been used as a pretest to determine the initial equality of the attitude of the two groups. This pretest data and the results of the analysis of variance appear in Table XVIII. As seen there, the two groups do not differ significantly at the 0.05 level of significance. However, the F ratio is close enough to the critical value to use the attitude pretest as a covariate in the analysis of the attitude data. Since the groups do not differ significantly on this measure, the attitude data is analyzed

TABLE XVIII

COMPARISON OF ATTITUDE DATA FOR
TREATMENT AND CONTROL GROUPS

Variable	Group	n	$\bar{x}$	s^2	Comparison of Means (F 1,61)
Attitude Pretest	Control	33	6.255	4.293	3.656
	Treatment	30	7.100	1.724	
Attitude Posttest	Control	33	5.594	3.936	.135
	Treatment	30	6.103	4.520	
Film Attendance	Control	33	1.576	2.313	.079
	Treatment	30	1.467	2.396	
Study Time	Control	33	2.286	0.933	.055
	Treatment	30	2.346	1.096	

Critical Region: $F(1,61)_{.05} > 4.00$

below, both with and without using the attitude pretest as a covariate.

As the results in Table XVIII indicate, when the means of each attitude variable are compared, no significant differences between the treatment and control groups appear. When the attitude measures are adjusted by using the attitude pretest as a covariate, the same result of no significant differences is observed. These results appear in Table XIX.

In addition to the statistically treated data which relates to the students' attitudes toward chemistry, there are some non-statistical findings concerning the students' attitudes which are presented here. Some of these findings concern attitudes toward chemistry and others concern attitudes toward the course itself and the method of instruction. These findings are presented here without formal statistical analysis. The data comes from a course evaluation which students completed at the end of the course and from informal comments made by students during the course.

All of the students were given a course evaluation form to complete immediately following the final examination in this course. Students rated several items and were then encouraged to write additional comments about the course. The results of the first part of this evaluation appear in Table XX. The first two items relate to the students' attitude toward chemistry and the second two items relate to the students' attitude toward the course that they received.

TABLE XIX

COMPARISON OF POSTTEST ATTITUDE OF TREATMENT AND CONTROL GROUPS USING THE ATTITUDE PRETEST AS A COVARIATE

Variable	F(1,60)	p
Attitude Posttest	0.006	>0.05
Study Time	0.009	>0.05
Film Attendance	0.684	>0.05

Critical Region: $F(1,60)_{.05} > 4.00$

When students were asked to rate the value of a basic chemistry course in a nursing curriculum on a scale of 1 to 5, both treatment and control groups gave this a below average rating. The treatment group rated this item slightly lower (2.07) than the control group (2.36). It is interesting that only 6.6% of the treatment group and 3.0% of the control group gave this item a rating which was above average.

When students were asked to rate the value of a basic chemistry course in a general education curriculum, both groups rated this as average. The treatment group rated this item slightly higher (3.10) than the control group (2.97).

The results of these first two items indicate that even though these student nurses felt that a general chemistry course has average value in a general education curriculum, it is their opinion that such a course has very little value in a nursing curriculum. This finding is supported by informal comments made by students during the course (especially at its beginning) in which they questioned student nurses being required to take chemistry. The results also indicate that students in both the control and treatment groups have similar feelings about the value of chemistry. No large differences appear in their attitude. This finding is consistent with the results obtained from the statistically treated attitude data. All of this data indicates that the method of instruction had no significant effect on the students' attitude toward chemistry.

TABLE XX

COURSE EVALUATION RESULTS

Item	Group	Low (1)	Below Ave. (2)	Ave. (3)	Above Ave. (4)	High (5)	Mean Numerical Rating
		Percent of Students from Each Group for Each Rating					
The value of a basic chemistry course in a nursing curriculum	Treatment	33.3	36.7	23.4	3.3	3.3	2.07
	Control	21.2	27.3	48.5	0.0	3.0	2.36
The value of a basic chemistry course in a general education curriculum	Treatment	3.3	26.7	36.7	23.3	10.0	3.10
	Control	12.1	15.1	42.4	24.3	6.1	2.97
The quality of instruction received in this course	Treatment	6.7	23.3	40.0	16.7	13.3	3.00
	Control	3.0	18.2	42.4	27.3	9.1	3.21
The difficulty of this course	Treatment	0.0	10.0	36.7	30.0	23.3	3.67
	Control	0.0	6.1	27.3	21.1	45.5	4.06

The second two items on the course evaluation relate to the students' attitudes toward the course itself. When asked to evaluate the quality of instruction that was received during the course, the treatment group rated this as average (3.00) and the control group rated it as just slightly above average (3.21). Although the two groups received very different methods of instruction, they rated the quality of instruction that they received very much alike.

Finally, students were asked to rate the difficulty of the course. On the average, both groups of students rated the course as being quite difficult. Although both groups rated the difficulty of the course as being above average, the treatment group did not feel the course was quite as difficult (3.67) as the control group did (4.06).

The results of the course evaluation do not show any conclusive differences between the attitude of the treatment and control groups. This is true concerning both attitude toward chemistry and attitude toward the course itself. Since on each item students in the treatment and control groups gave very similar ratings, it does not appear that the method of instruction had much effect on attitudes of either kind.

Although it was not one of the purposes of this experiment to compare the attitudes of students in the two groups toward the method of instruction that they received, findings which are pertinent to these attitudes are also presented here without formal statistical treatment. The sources of data which provided information about the students' attitudes toward the method of instruction are the informal comments made by students on the evaluation form and those made during the course.

To begin with, students in the control group did not comment on the method of instruction that they received. The lecture method was familiar to them and they seemed to feel secure with it. The comments made by students in the control group dealt mostly with the value of a course in basic chemistry in a nursing curriculum and the difficulty of chemistry for them.

Students in the treatment group, on the other hand, made many comments which related to the method of instruction that they received. Some students liked the method very much. They liked the individual attention that they could receive, and they liked being able to work at their own pace. Other students disliked the experimental method. These students seemed to feel insecure in this method and thought that they were missing something by not being in a lecture class. These students did not think that they should have to take a chance with something as difficult for them as chemistry. On many occasions, even on the final course evaluation, some of these students in the treatment group said that they could have learned more in a lecture class.

These comments were made in spite of the fact that all of the students knew the results of each test and could see that students in the treatment group were doing at least as well as students in the control group.

The comments made by some of the students in the treatment group seem to indicate that these students had felt anxiety about taking chemistry, and a new method of instruction which contained elements of self-study frightened them more. This may have caused their negative attitude toward the experimental method of instruction. Students in the control group, on the other hand, did not blame the method of instruction for the difficulty of the course because the lecture method was familiar to them. To them chemistry was difficult, but they did not associate this with the method of instruction.

In addition to the students who liked the experimental method and those who felt insecure with it, there was a third group. These students liked the individualized approach, but they would have preferred not to have been required to attend class for organized group work. These students would have preferred to have been completely on their own with the learning guide.

Although a variety of feelings concerning the experimental method of instruction were expressed, the most important finding seems to be this: Students who are already anxious about a course, because of its difficulty for them, are not very willing to accept a new method of instruction, especially when it calls for additional self-study.

In summary, the statistical analysis of the achievement data indicates that student achievement was not affected by the method of instruction used. However, there is a statistically non-significant increase in the difference between the achievement of the two groups which gets larger with time. If this trend were to continue, the achievement of the treatment group would soon become significantly higher than that of the control group. Both statistical and non-statistical treatment of data relating to the students' attitude toward chemistry indicate that the method of instruction had no significant effect on attitude toward chemistry. The data which relates to the students' attitude toward the experimental method of instruction, shows that there are a variety of opinions about the method. Although some of the students favored the method, a sizable group felt insecure when aspects of self-study were used in a course which was difficult for them.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

In this chapter the study is summarized and the conclusions that can be drawn from the data are enumerated. This is followed by recommendations for further study regarding the individualization of instruction.

SUMMARY

The problem was to determine if a type of individualized instruction could be used in a chemistry course for student nurses without sacrificing academic achievement on the part of these students.

The primary purpose of this study was to determine if the academic achievement of freshman student nurses taking chemistry would be affected by using a technique of individualized instruction which utilized a learning guide and small group discussion by comparing these students with others in a class taught by the traditional lecture method.

A second purpose of this study was to determine if the use of this method of individualized instruction would affect students' attitudes toward chemistry when compared with the attitude of students taught by the lecture method.

The study was designed so that two groups of freshman student nurses were used in the experiment. The first group was comprised of students who were randomly selected to receive the experimental method of instruction. The second group was comprised of the remaining students who were not selected for the experimental method of instruction. They served as a control group.

Additional aspects of the study are enumerated below:

1. Control Group. The method of instruction used with the control group was the lecture. Students in the control group met for two one-hour lectures each week.

2. Treatment Group. The method of instruction used with the treatment group was individualized instruction with group discussion. Students in the treatment group worked individually through a teacher-prepared learning guide during a weekly two-hour work session. The learning guide contained written explanations of chemical principles and concepts, questions to be answered, and problems to be solved. An example of a unit from the learning guide appears in Appendix A.

The learning guide consisted of two parts. The first part was required of all students and knowledge of this material was necessary for C-level achievement. The second part was optional and contained learning materials for those students who could master the required materials quickly. Some knowledge of this material was expected of A and B students.

All students in the treatment group received both parts of the learning guide. Students worked in heterogeneous small groups of four or five members on the learning guide for approximately the first one hour and thirty minutes of the two-hour session. During this time the students worked individually, but they were also expected to help students in their group who were having difficulty. At the end of the one hour and thirty minute session, students broke up into homogeneous small groups for discussions of the topic that they were studying. During these discussions, the students used lists of questions which the instructor had prepared to assess their knowledge of the subject. When the discussion was completed, the students continued to work on the learning guide. After the required work was completed, students began working on the optional materials. The instructor was present during the entire two-hour session to assist students, but he did not lecture to the treatment group.

3. Both groups were taught by the same instructor.

4. Both the treatment and control groups received the same list of questions to assess their knowledge of the required and optional materials. The treatment group used these in organized discussion groups and the control group used these on their own. Correct answers to these questions were posted each week. An example of the Assessment Questions appears in Appendix A.

5. Each week the two groups received the same list of topics to be studied along with specific references for each topic. An example of a list of topics is in Appendix A.

6. Both groups had material differentiated into required and optional sections. The treatment group received this material from the learning guide and the control group received this material from the lectures.

7. Each week both groups received the same list of objectives which related to the topic being studied. An example of the lists of objectives appears in Appendix A.

8. Both groups of students took the same tests at the same time.

9. The population of the study was limited to the freshman student nurses taking chemistry at the Evanston Hospital School of Nursing (Evanston, Illinois) during the 1970-1971 school year.

The experimental data for the study came from these sources: (1) teacher-prepared tests of chemistry achievement, (2) the Scale to Measure Attitude Toward Any School Subject, and (3) several behavioral indications of interest in chemistry, namely, the amount of time spent studying chemistry, and attendance at optional films. Both attitude and achievement data were analyzed statistically by using the analysis of variance technique. When it was appropriate, pretest measures were used as covariates to adjust for initial differences between groups. Assumptions underlying analysis of variance and covariance were tested in each case and the results of these tests appear in Appendix E.

Since students in both the control and treatment groups did not all take their medical and surgical nursing courses in the same order, this data was also analyzed to determine the effect of the order of taking the two nursing courses.

Several basic assumptions were made in this study and these appear below.

1. The SCAT test and first semester grade point average could be used to measure general academic ability.

2. The written Scale to Measure Attitude Toward Any School Subject dould be used to measure attitude toward chemistry.

3. Since it has been reported that behavioral measures are valid indicators of science interest, the attendance at optional chemistry films and time spent studying chemistry would be reasonable indicators of student attitude toward chemistry.

4. The teacher-prepared tests, which were written from the lists of behavioral objectives that the students received each week, could be used to measure student achievement in chemistry.

5. The Cooperative Science Test in Chemistry could be used to measure initial knowledge of basic chemistry.

6. Since both the treatment and control groups

were experiencing something new, the Hawthorne effect would be equalized.

7. A class session of two hours each week (treatment group) was equivalent to two class sessions of one hour per session each week (control group).

One finding from this study was that there was no significant difference between students who took medical or surgical nursing first in either their achievement in chemistry or their attitude toward chemistry. Another finding from the study was that there was no statistically significant difference between the control and treatment groups in achievement in chemistry. However, there was a statistically non-significant increase in the difference between the achievement of the two groups which became larger with time. If this trend were to continue, the achievement of the treatment group would soon become significantly higher than that of the control group. Analysis of all the attitude data showed that there were no significant differences between the control and treatment groups in their attitude toward chemistry. From the data which related to the students' attitudes toward the experimental method of instruction, it was found that there were a variety of opinions about the method. Although some of the students favored the method, a sizable group felt insecure when aspects of self-study were used in a course which was difficult for them.

CONCLUSIONS

The following conclusions were drawn from the data at the end of the experiment.

1. The order of taking medical and surgical nursing has no effect on either achievement in chemistry or attitude toward chemistry.

2. A method of individualized instruction which uses a learning guide and small group discussion can be used in a chemistry course for student nurses without sacrificing academic achievement. The achievement of students in the experimental class was at least as high as the achievement of students who were in the control class. In fact, the students in the experimental class scored higher, although non-significantly so, on seven of eight parts of the achievement tests. Also, it appears from the data that if the experiment had run for a longer period of time, the achievement of the students who were in the experimental class would have become significantly greater than that of the students in the control class. Therefore, not only can the individualized method be used without sacrificing academic achievement, but it also appears that once accustomed to the method, students may achieve more than in a traditional class. This interpretation, of course, needs further study.

3. Facts, principles, and concepts of chemistry can be transmitted to students as effectively by means of a written learning guide as by the traditional lecture.

The achievement of students in the experimental class which received material by the vehicle of the learning guide was at least as high as the achievement of students in the control class which received material by the vehicle of the oral lecture. Once this conclusion is made it can be pointed out that the written learning guide also has the advantage of being adaptable to students of different abilities in the same class. Students of different abilities could use different forms of the same learning guide.

4. The use of this method of individualized instruction has the advantage of freeing the instructor to work with individual students who have special problems. Although this is usually considered to have intrinsic value, the practical value of it may be questioned. Specifically, in this experiment the more individualized attention did not result in significantly greater achievement on the part of the students.

5. The data which relates to student attitudes toward chemistry shows that the method of instruction has no significant effect on student nurses' attitudes toward chemistry. Specifically, there were no significant differences between the treatment and control group on the attitude posttest, the time reported spent studying chemistry, or the number of optional films attended.

6. Comments made by students in the treatment group indicate that there were a variety of feelings concerning

the experimental method of instruction. Some students liked the method of instruction because of the closer personal attention that they received. Other students disliked the method because they were afraid that they would not learn as much in the experimental class as they would in a lecture class. Still others liked learning by means of the learning guide but wanted to do it on their own at their own time rather than in organized groups. Some of the students' suggestions could be tried and tested in other experiments.

RECOMMENDATIONS FOR FURTHER STUDY

This study raises several questions which have not yet been answered. These questions in turn suggest areas for further study and experimentation. Some of the questions and problems that were raised by this study appear below.

1. Can the results of this experiment be replicated by someone else?

2. Would the same results be obtained if a group of students other than student nurses were used in the experiment?

3. Would the apparent difference in the achievement of the two groups become statistically significant if the experiment were run for a longer period of time?

4. Did the students need a certain amount of time to become accustomed to the new method of instruction before a maximum achievement level could be reached?

5. Would the same results be obtained if the discussion groups were not included in the experimental method?

6. Would the same results be obtained if the students were allowed to form their own study groups rather than be assigned to groups?

7. Would the same results be obtained if students were not required to come to an organized class to work, but were allowed to work on the learning guide on their own and on their own time?

8. Do high, middle, or low ability students achieve more from one method or the other?

The answers to these questions would provide additional information regarding the type of individualized instruction that can be used effectively as a means of teaching a group of students of heterogeneous ability or background in the same course.

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APPENDIX A

A SAMPLE UNIT FROM THE LEARNING GUIDE

Unit I Atomic Structure

List of Topics and References

Topics	References
Part 1	
a. Basic Review	ASB, frames 1-166
b. Parts of the atom and their change	CHEMS, 6-1.1, 6-1.2
c. Atomic number	CHEMS, 6-1.4
d. The sizes of atoms	CHEMS, 6-1.3; 20th Cent, pp. 27-28; CHEMS, 14-2.3
e. Mass numbers and isotopes	CHEMS, 6-1.5
f. Energy levels	20th Cent, pp. 29-30
Part 2	
a. Energy levels	QV, pp. 219-222
b. Quantum numbers	QV, pp. 223-224
c. Atomic orbitals	CHEMS, pp. 261-263; QV, pp. 237-244, pp. 225-232

Key to References

ASB (Dawson, Charles R., ed. Atomic Structure and Bonding, A Basic Systems Program. New York: Appleton-Century-Crofts, 1962.)

CHEMS (Pimentel, George C., ed. Chemistry: An Experimental Science. San Francisco: W. H. Freeman and Co., 1963.)

20th Cent. (Routh, Joseph I. 20th Century Chemistry. Philadelphia: W. B. Saunders Company, 1963.)

QV (Quagliano, J. V., and L. M. Vallarino. Chemistry. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1969.)

Objectives for Unit I - Atomic Structure

These are statements of terminal behaviors which the student should be able to perform after completing this unit.

Part 1

a. Choose the correct definition of a term from a list of definitions and choose the term corresponding to a given definition from a list of terms.

1) nucleus
2) electron
3) proton
4) neutron
5) atomic number
6) atomic weight
7) mass number
8) discreet energy levels
9) isotope
10) electron cloud
11) octet rule
12) shell
13) sub-shell

b. Distinguish between correct and incorrect statements of fact regarding:

1) components of an atom
2) composition of the nucleus of an atom
3) mass and charge of each component of an atom
4) energy of electrons in relation to their distance from the nucleus
5) details of the Rutherford experiment
6) number of electrons in each principal energy level

c. Understand the relationship between the components of an atom and its charge, mass, and atomic number.

1) Calculate the relative mass and charge of an atom from a knowledge of the number of electrons, protons and neutrons.
2) Calculate the atomic weight of a mixture of isotopes knowing the number of electrons, protons, and neutrons in each isotope and the percentage of each isotope.

Part 2

a. Choose the correct definition of a term from a list of definitions and choose the term corresponding to a given definition from a list of terms.

1) atomic orbital
2) ground state
3) excited state
4) quantum number
5) Hund's Rule
6) Pauli Exclusion Principle
7) Building up principle

b. Distinguish between correct and incorrect statements of fact regarding:

1) the filling of atomic orbitals
2) the shapes of atomic orbitals
3) the movement of an electron from the ground state to an excited state

c. Recognize correct and incorrect representations of the electron configuration of an element given the atomic number of that element.

d. Calculate the energy needed to move an electron from one energy level to another given the energy of the electron at each level.

UNIT I - ATOMIC STRUCTURE

Part 1

In this unit you will study the structure of the atom. You will learn about its basic components and some of the ways in which these components interact. If you are very unsure of this material, you can review some basic ideas by going through the first three sections of the programmed text, Atomic Structure and Bonding. The sections are those on The Atom, Charge, and Electron Configuration.

1. Parts of the Atom and Their Charge

   a. Read CHEMS, sections 6-1.1 and 6-1.2

      (1) Name the three major components of an atom.

      (2) Draw a simple model to show the relationships among these components.

      (3) How much does each of these contribute to the mass of an atom? (Give the mass of an electron as a decimal.)

      (4) What is the charge of each of these components?

      (5) Describe the composition of the nucleus of an atom.

      (6) Approximately what proportion of the mass of an atom is contributed by the nucleus?

   b. Atoms gain or lose electrons in chemical reactions but they do not gain or lose protons. Therefore, in order for the charge of an atom to change, it must gain or lose electrons. Changes in proton number occur only in nuclear reactions. This is the subject of radioactivity which will be studied later.

(1) If an electron is added to any neutral atom, what is the charge on that atom?

(2) If two electrons are removed from any neutral atom, what is the charge on that atom?

(3) An atom of the element magnesium has 12 neutrons and 12 protons in its nucleus. How many electrons does a neutral magnesium atom have?

(4) A magnesium ion with a charge of plus 2 has:

(a) How many electrons?

(b) How many neutrons?

(c) How many protons?

2. Atomic Number

a. Read CHEMS, section 6-1.4

(1) Define atomic number in your own words.

(2) If you know the number of electrons and protons in any neutral atom, tell how to determine the atomic number of that atom.

(3) Give the atomic number of two elements and tell how many electrons and protons are in each atom of that element.

3. The Sizes of Atoms

a. Read CHEMS, section 6-1.3

(1) From what you have read here, could you draw on this piece of paper a model which accurately represents the relative size of the nucleus of an atom to the rest of the atom?

(2) With so much empty space present in an atom, why do you suppose we cannot see through solid objects?

b. Read 20th Cent, pp. 27-28. Read the sections on the structure of the atom and the nucleus.

(1) Draw a model of an alpha particle showing the number of neutrons, electrons, and protons.

(2) Summarize the Rutherford experiment and explain the contribution that Rutherford made to our knowledge of the atom.

c. For a more detailed discussion of the Rutherford experiment read CHEMS, section 14-2.3

4. <u>Mass Number and Isotopes</u>

a. We said earlier that each of the atoms of an element has the same number of protons in its nucleus. We can identify any element by the number of protons that it contains. This number is the atomic number. Any atom that has eight protons is oxygen, no matter how many electrons or neutrons that it has. Any atom that has seven protons is nitrogen, no matter what the rest of the atom looks like.

All atoms of an element do not, however, have the same mass. The weights of the different oxygen atoms, for example, vary. Some of them are heavier than others.

(1) Almost all of the mass of an atom is contributed by the protons and neutrons. Which of these do you suspect will vary in atoms of the same element having different weights?

(2) Explain your answer.

b. Atoms of an element which have different numbers of neutrons are called <u>isotopes</u>. These atoms have the same atomic number but different mass number.

c. Read CHEMS, section 6-1.5

(1) Draw a model showing the number of electrons, protons and neutrons in deuterium, an isotope of hydrogen. Compare this to the model of an alpha particle that you drew before.

(2) Draw a model showing the number of electrons, protons and neutrons in an atom of hydrogen.

(3) An atom of an element contains 17 protons and 20 neutrons. Name the element.

(4) Define atomic number.

(5) Define mass number.

d. Since most naturally occurring elements are composed of mixtures of isotopes, the atomic weights for these elements are not whole numbers. They represent the average weight of the isotopes involved. Ordinary chlorine, for example, has 17 protons and 18 neutrons and a mass number of 35. The naturally occurring isotope of chlorine has 17 protons, 20 neutrons and a mass number of 37. To calculate the atomic weight of the mixture of these isotopes as they exist in nature, we must know the percentage of each isotope. We know that chlorine-37 makes up about 24.6% of the chlorine in nature and that chlorine-35 makes up about 75.4% of the chlorine in nature. The average weight is called the atomic weight of naturally occurring chlorine. It is equal to:

$$\text{Average} = \frac{(75.4\%)(35) + (24.6\%)\ (37)}{100\%} = 35.5$$

The atomic weight that is reported for chlorine is based on this mixture of isotopes and is approximately 35.5

(1) Naturally occurring boron is made up of two isotopes. Boron-10 makes up about 19% of the total and Boron-11 makes up about 81% of the total.

(a) How many protons, electrons and neutrons are in each of these isotopes?

(b) Calculate the atomic weight that should be reported for naturally occurring boron.

(2) If the charge of the nucleus and the arrangement of electrons surrounding it are the most important considerations in the way that atoms behave toward other atoms, what differences would you expect to see in the way oxygen-16 and oxygen-18 behave toward other atoms? Explain.

5. <u>Energy Levels</u>

a. The electrons which surround the nucleus of an atom are located at discreet distances from the nucleus, and these distances represent different energy levels. The electrons closest to the nucleus are at the lowest energy level and the electrons farthest from the nucleus are at the highest energy level.

b. Read 20th Cent, p. 29-30 (Electron Shells and Electron Subshells)

(1) How many electrons can occupy energy levels 1,2,3 and 4? (K,L,M and N)

(2) How many electrons form a stable arrangement in each shell?

(3) What is the octet rule? If you can't find the answer here, try to find it in another reference.

(4) What is true of electrons in the same shell but different subshells?

(5) Tell how many subshells there are in the K,L,M and N shells.

Assessment Questions for Unit I - Atomic Structure

Part I

1. Where are electrons located in an atom and how much do they contribute to the mass of an atom?

2. Carbon-12 has an atomic number of 6 and a mass number of 12. Tell how many electrons, protons and neutrons are present in a neutral atom of carbon-12.

3. The atomic number of calcium is 20. The atomic weight of calcium is given as 40.1. Explain why the atomic weight is given as a decimal and not a whole number.

4. What must happen to an atom of magnesium-24 for the charge on it to change from zero to plus 2? How is the charge on any atom changed?

5. What significance did Rutherford's experiment have in developing our knowledge of atomic structure? Tell what the experiment was and the information that was obtained from it.

6. What is meant by "atomic number"?

7. What is meant by the terms "atomic weight" and "mass number"?

8. Define "energy level."

9. What is the relationship between the distance an electron is from the nucleus and the energy level of the electron?

UNIT 1 - ATOMIC STRUCTURE

Part 2

1. <u>Energy Levels</u>

   a. Read QV, pp. 219-222

   b. The simplest system for studying the relationship between a nucleus and the surrounding electrons is the hydrogen atom, because a hydrogen atom is made up of just one electron and one proton. The electron can exist at several different distances from the center of the nucleus.

      (1) What is the term used to describe the various distances that an electron can be from the nucleus?

      (2) Compare the stability of a hydrogen atom in the ground state and excited state.

      (3) Compare the electrostatic attraction between the nucleus and electron of a hydrogen atom when the electron is in the energy level corresponding to n=1 and when it is in the energy level corresponding to n=3.

      (4) Given that the energy value of the hydrogen atom in the ground state is -313.6 kcal and the energy value of the hydrogen atom in the first excited state (n=2) is -78.4 kcal, explain what is needed to move an electron from the ground state to the first excited state. Tell whether energy must be added or taken away and how much.

      (5) If a hydrogen atom in the ground state is irradiated by an energy source emitting 5.5 ev of energy, what energy level will the atom be in after it has been irradiated? Explain.

2. Quantum Numbers

a. You have now been introduced to the principal quantum number, n. The principal quantum number refers to the average distance that an electron is from the nucleus of an atom. There are three additional quantum numbers which are used to define the energy of an electron in an atom. The second quantum number describes the shape of the orbital that an electron is in. (Orbitals will be discussed in detail in the next section.) The third quantum number is the magnetic quantum number, m. It describes the energy of electrons having the same orbital quantum number under the influence of a magnetic field. For example, there are three orbitals called p orbitals which are energetically equivalent in the absence of a magnetic field, but which differ in the presence of a magnetic field. The fourth quantum number is the spin quantum number, s. An electron can spin in one of two directions around its own axis. The spin quantum number can be either $+\frac{1}{2}$ or $-\frac{1}{2}$.

(1) In your own words explain what each of the four quantum numbers represents.

(a) Principal quantum number

(b) Orbital quantum number

(c) Magnetic quantum number

(d) Spin quantum number

b. For a detailed explanation of quantum numbers, read QV, pp. 223-224.

3. Atomic Orbitals

a. The energy of an electron is determined primarily by its principal quantum number, n; that is, by the distance that the electron is from the nucleus of the atom. In our model of the atom, however, we find that there may be sub-levels of different energy in the principal levels. The sub-levels are called orbitals. In each orbital there may be a maximum of two electrons. When two electrons are present, they must spin in the opposite direction from each other. In other words, they must have opposite spin quantum numbers. Orbitals are named by identifying the principal quantum number (1,2,3,4 etc.) and a letter which indicates the shape of the orbital (s,p,d,f). Orbitals are then named 1s, 2s, 1p, 4s, 4f, etc. Since an orbital may have 1 or 2 electrons in it, a way is necessary to give this information. A superscript is usually used to tell the number of electrons in a particular orbital:

$1s^1$, $1s^2$, $2p^1$, $3s^2$, $3p^2$

b. For a description of the shapes of the orbitals see CHEMS, pp. 261-263, and QV, pp. 237-244.

(1) Describe the shape of the s, p, and d orbitals.

(2) How many electrons can be present in each orbital?

(3) How many s, p, d and f orbitals are there in each of the first four principal energy levels?

(4) Describe an electron in a 3p orbital. How far is it from the nucleus? (In terms of the principal quantum number?) Where can the electron in the 3p orbital be located? Draw a picture of a 3p orbital.

c. As atoms increase in size they contain more protons and more electrons. The electrons occupy specific orbitals, and the filling of these orbitals follows specific rules. Read QV, pp. 225-232 for rules concerning the filling of atomic orbitals and examples of the electrons filling the orbitals.

(1) Give the ground state electron configuration of the first ten elements. (atomic numbers 1-10)

Example: Oxygen-8: $1s^2 2s^2 2p^4$.

(2) For these ten elements draw a model of the individual orbitals and the electrons in each.

Example. Oxygen-8:

(↑↓)	(↑↓)	(↑↓)	(↑)	(↑)
1s	2s	$2p_x$	$2p_y$	$2p_z$

(3) What is the Pauli Exclusion Principle?

(4) What is Hund's Rule? Give two examples where Hund's Rule is followed as the orbitals are filled.

Assessment Questions for Unit I - Atomic Structure

Part 2

1. If the energy of an electron is 50 kcal lower in one energy level than it is in the next, and the electron is irradiated with a 40 kcal energy source, where will the electron end up after this irradiation? Explain.

2. Compare the principal quantum number and the spin quantum number.

3. What are quantum numbers used for?

4. What are the differences between an s orbital and a p orbital?

5. Compare and contrast a 1s orbital and a 2s orbital.

6. Draw a model showing the electrons in each orbital for an element having an atomic number of 14.

APPENDIX B

TEST OF ATTITUDES TOWARD CHEMISTRY

TEST OF ATTITUDE TOWARD CHEMISTRY

<u>Instructions</u>

Please read each of the following statements carefully. Put a check mark (✓) if you agree with the statement. Put a cross (X) if you disagree with the statement. If you simply cannot decide about a statement, you may place a question mark beside it.

There are no right or wrong answers to these questions. People differ in their opinions on them. Just indicate your own opinion by checking those statements with which you agree and placing a cross beside those with which you disagree.

____ 1. No matter what happens, this subject always comes first.

____ 2. I would rather study this subject than eat.

____ 3. I love to study this subject.

____ 4. This subject is of great value.

____ 5. This subject has an irresistible attraction for me.

____ 6. I really enjoy this subject.

____ 7. This subject is profitable to everybody who takes it.

____ 8. This subject develops good reasoning ability.

____ 9. This subject is very practical.

____ 10. Any student who takes this course is bound to be benefited.

____ 11. This subject teaches me to be accurate.

____ 12. This subject is a universal subject.

____ 13. This subject is a good subject.

_____ 14. All of our great men studied this subject.

_____ 15. This subject is a cultural subject.

_____ 16. All lessons and all methods used in this subject are clear and definite.

_____ 17. This subject is O.K.

_____ 18. I am willing to spend my time studying this subject.

_____ 19. This subject is not receiving its due in public high schools.

_____ 20. This subject saves time.

_____ 21. This subject is not a bore.

_____ 22. This subject is a good pastime.

_____ 23. I don't believe this subject will do anybody any harm.

_____ 24. I am careless in my attitude toward this subject, but I would not like to see this attitude become general.

_____ 25. I haven't any definite like or dislike for this subject.

_____ 26. This subject will benefit only the brighter students.

_____ 27. My parents never had this subject; so I see no merit in it.

_____ 28. I could do very well without this subject.

_____ 29. Mediocre students never take this subject; so it should be eliminated from schools.

_____ 30. The minds of students are not kept active in this subject.

_____ 31. I am not interested in this subject.

_____ 32. This subject does not teach you to think.

_____ 33. This subject is very dry.

_____ 34. This subject reminds me of Shakespeare's play-- "Much Ado About Nothing."

____ 35. I have no desire for this subject.

____ 36. I have seen no value in this subject.

____ 37. I would not advise any one to take this subject.

____ 38. This subject is based on "fogy" ideas.

____ 39. This subject is a waste of time.

____ 40. It is a punishment for anybody to take this subject.

____ 41. This subject is disliked by all students.

____ 42. I look forward to this subject with horror.

____ 43. I detest this subject.

____ 44. This subject is the most undesirable subject taught.

____ 45. I hate this subject.

APPENDIX C

STUDENT FORM FOR RECORDING STUDY TIME

Record of Time Spent Studying Chemistry

On this form I would like you to keep a daily record of the amount of time that you spend studying chemistry outside of class. At the end of each week, add the hours together to give the total for the week.

Estimate your study time to the nearest quarter hour. ($1\frac{1}{2}$ hours, $2\frac{1}{4}$ hours, etc.). Put a zero for the days that you don't do any studying. Don't leave any places blank.

Keep this record with your chemistry notes and bring it to class each day.

	Week Number			
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				
Total				

APPENDIX D

TEACHER-MADE ACHIEVEMENT TESTS

ACHIEVEMENT TEST I

Part I

1. Isotopes are:
   a. atoms of the same element having different numbers of neutrons.
   b. elements having the same weight but different numbers of protons.
   c. atoms of different elements which weigh the same.
   d. atoms of the same element having different numbers of protons.

2. The total number of protons and neutrons in an atom is equivalent to its:
   a. atomic number
   b. atomic weight
   c. mass number
   d. molecular weight

3. The number of electrons that can be present in the second principal energy level of an atom is:
   a. 2
   b. 6
   c. 8
   d. 18

4. An atom has six electrons, six protons and six neutrons. Its mass number is:
   a. 6
   b. 12
   c. 18
   d. 32

5. An atom which has lost three electrons has a charge of:
   a. -3
   b. +3
   c. 0
   d. The charge cannot be determined from this information.

6. The nucleus of an atom having atomic number 7 and mass number 14 contains:
   a. 7 electrons and 7 protons
   b. 14 protons and 7 neutrons
   c. 14 neutrons
   d. 7 protons and 7 neutrons

7. One of the most surprising findings of Rutherford's experiment was that:
   a. Some He nuclei were deflected at large angles by a piece of gold foil.
   b. Many He nuclei passed through a piece of gold foil undeflected.

c. Alpha particles are postively charged.
d. Gold foil is composed of atoms.

8. Element X exists in nature in two forms. One form has 5 protons, 5 electrons and 5 neutrons. The other form has 5 protons, 5 electrons and 7 neutrons. Approximately 25% of the atoms of this element are in the first form and 75% in the second form. What atomic weight should be recorded for element X?
   a. 10
   b. 11.5
   c. 12
   d. 12.5

9. The total number of protons in an atom is equivalent to its:
   a. atomic number
   b. atomic weight
   c. mass number
   d. molecular weight

10. An atom has 3 electrons, 3 protons and 3 neutrons. Its charge is:
   a. +3
   b. -3
   c. 0
   d. +6

11. Which of these statements best expresses the relationship between the energy of an electron and its distance from the nucleus of an atom?
   a. The closer an electron is to the nucleus the higher is its energy.
   b. The farther an electron is from the nucleus the higher is its energy.
   c. The energy of an electron does not depend upon its distance from the nucleus but upon its spin only.
   d. The energy of an electron does not depend upon its distance from the nucleus but upon the size of the nucleus.

12. The Group IIA elements have how many electrons in their outer shell?
   a. 1
   b. 2
   c. 6
   d. It varies for each element in this group.

13. Elements in the third period of the periodic table have how many electrons in their outer shell?
   a. 2
   b. 3
   c. 5
   d. It varies for each element in this period.

14. Which statement best expresses the relationship between atomic structure and periodically recurring properties?
    a. Elements which have the same number of electrons in their first and second shells have similar properties.
    b. Elements which have the same number of electrons in their first shell only, have similar properties.
    c. Elements which have similar atomic structure have similar properties.
    d. There is no relationship.

15. The electrons in the outer shell of an atom are called:
    a. valence electrons
    b. orbital electrons
    c. bonding electrons
    d. stable electrons

16. As one proceeds from left to right in a period of the periodic table:
    a. each atom has one more neutron than the atom preceding it.
    b. the atoms become more highly charged.
    c. the properties of these elements are very similar.
    d. every atom has one more electron and one more proton than the atom preceding it.

17. The symbol for silver is:
    a. Si
    b. Sl
    c. Ag
    d. Au

18. Mg is the symbol for:
    a. Magnesium
    b. Manganese
    c. iron
    d. lead

19. Na is the symbol for:
    a. Noranium
    b. Natium
    c. Sodium
    d. Potassium

20. An element with atomic number 20 is in:
    a. period 2
    b. period 3
    c. period 4
    d. period 5

21. Elements X and Y are both in the same group in the periodic table. Which of these statements is true?
   a. X and Y have different charges.
   b. X and Y have the same charges but very different properties.
   c. X and Y have similar properties but their atomic structures are not similar.
   d. The atomic structure and properties of X and Y are similar.

22. Element Z has the following orbital electron configuration:

1s	2s	$2p_x$	$2p_y$	$2p_z$
↑↓	↑↓	↑↓	↑↓	↑

   How many bonding orbitals does element Z have?
   a. 0
   b. 1
   c. 4
   d. 5

23. Elements M and L combine to form a molecule. The electron configurations for these elements are:

	1s	2s	$2p_x$	$2p_y$	$2p_z$	3s
L	↑↓	↑↓	↑	↑	↑	
M	↑↓	↑↓	↑↓	↑↓	↑↓	↑

   The formula for the compound that forms between M and L is probably:
   a. M_3L
   b. M_2L
   c. ML
   d. ML_3

24. The elements having the highest ionization energy are found:
   a. in the first group of the periodic table.
   b. in the fourth period of the periodic table.
   c. on the left side of the periodic table.
   d. on the right side of the periodic table.

25. An ion is:
   a. the same as a hydrogen atom.
   b. any uncharged atom.
   c. a charged atom or group of atoms.
   d. formed whenever the number of electrons and protons in an atom is equal.

26. Lithium has one valence electron and chlorine has seven valence electrons. Which of these compounds would be most likely to form?
 a. LiCl
 b. $LiCl_2$
 c. $LiCl_7$
 d. Li_7Cl

27. Ionization energy is:
 a. the energy required to remove an electron from an atom.
 b. the energy released when a neutral atom is formed.
 c. the energy required to form a neutral atom.
 d. the energy required to form a stable octet.

28. In a covalent bond:
 a. there is an attraction between oppositely charged ions.
 b. a pair of electrons is shared by two atoms.
 c. electrons are not attached to any atoms but are moving freely among all the atoms.
 d. protons are lost from one atom and gained by another.

29. Given the ionization energy values for these atoms, which bond would most probably be the most polar?

Atom	Ionization Energy (ev)
U	17.4
V	16.2
W	9.1
X	4.5

 a. U-W
 b. V-W
 c. U-X
 d. V-X

30. A negative ion is formed when:
 a. electrons are removed from a neutral atom.
 b. electrons are added to a neutral atom.
 c. a covalent bond joins two atoms.
 d. a molecule is formed.

31. When a molecule forms:
 a. the molecule has a lower energy value than the atoms which make it up.
 b. the molecule has a higher energy value than the atoms which make it up.
 c. the molecule has the same energy value as the atoms which make it up.
 d. This cannot be determined. It varies for each molecule.

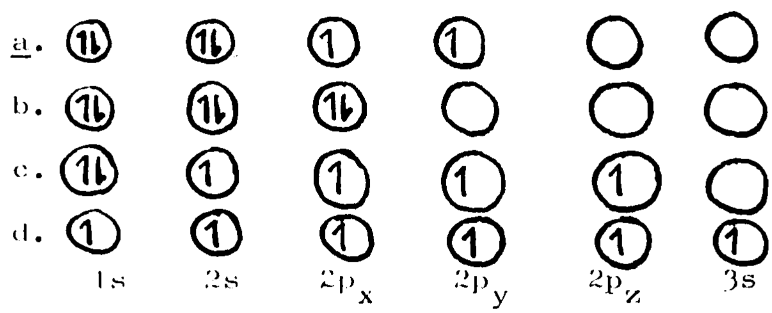
32. The ionization energy of element Q is 6.5 ev and the ionization energy of element R is 13.0 ev. A covalent bond forms between the atoms of these elements forming compound QR. Where would you expect the bonding electron pair to spend most of its time?
a. on element R
b. on element Q
c. in between R and Q
d. This cannot be determined.

Part 2

33. The orbital electron configuration of an atom having an atomic number of 14 can be represented as:
a. $1s^2 2s^2 2p^3 3s^2 3p^4 3d^6$
b. $1s^3 1s^2 2s^1 3p^6$
c. $1s^3 2s^2 2p^2 3s^4 3p^2 4s^1$
d. $1s^2 2s^2 2p^6 3s^2 3p^2$

34. A spherical orbital which contains two electrons is a/an ________ orbital.
a. s
b. p
c. d
d. f

35. The orbital electron configuration of carbon (atomic number 6) is correctly represented as:



36. Only two electrons can be present in any one orbital is a statement of:
a. Hund's Rule
b. The building up principle
c. Spin quantum law
d. The Pauli Exclusion Principle

37. The ground state energy of an electron is 10.5 ev, and the energy of this electron when n=2 is 4.5 ev. If this electron in the ground state is irradiated with an energy source equivalent to 3.0 electron volts, the electron will:

a. be moved to the first excited state.
b. be moved to the second excited state.
c. stay in the ground state.
d. be moved about half-way between the ground state and the first excited state.

38. There is a kind of orbital which is shaped like a dumbell. There are three of these orbitals which are equivalent in energy. How many electrons can each of this kind of orbital hold?
a. 2
b. 3
c. 4
d. 6

39. s-block elements are:
a. a group of elements in the periodic table beginning with "s" such as silver and strontium.
b. elements which have their highest energy electron in an s orbital.
c. elements which have electrons in the s orbital.
d. elements which have electrons in the s shell and which can form cube shaped compounds.

40. Transition elements are the same as:
a. s-block elements
b. p-block elements
c. d-block elements
d. t-block elements

41. Period 2 of the periodic table is the same as:
a. Group II
b. the very short series
c. the first short series
d. the second short series

42. Look at the following electron configurations and tell which elements have similar properties.

1. $1s^2\ 2s^2\ 2p^6\ 3s^1$
2. $1s^2\ 2s^2\ 2p^6\ 3s^2$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 4s^2$

a. 1 and 2
b. 1,2 and 3
c. 2 and 4
d. 2,3 and 4

43. Row 2 of the periodic table has 8 elements in it because:
a. there are 4 orbitals with a capacity of 8 electrons that can be filled before getting to the next inert gas arrangement.
b. there are 8 orbitals to be filled in the second row.

c. that is the way it was originally drawn.
d. row 1 has 8 elements in it and 8 is a stable number.

44. How many clusters of orbitals having approximately the same energy are there for Argon having atomic number 18, and how many orbitals are there in each cluster?
a. One cluster with nine orbitals.
b. Three clusters with 2, 8 and 8 orbitals in the three clusters.
c. Two clusters with 9 orbitals in each cluster.
d. Three clusters with 1, 4 and 4 orbitals in the three clusters.

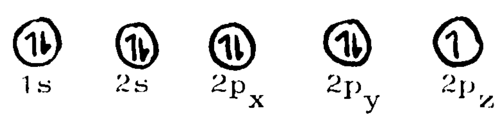
45. Given that the electronegativity value of Li is 1.0, Cl is 3.0, H is 2.1 and F is 4.0, tell which of the following lists of compounds is arranged in order of increasing polarity.
a. LiH, HF, LiCl, LiF
b. LiF, LiCl, HF, LiH
c. LiH, LiF, LiCl, HF
d. HF, LiCl, LiH, LiF

46. How many pairs of electrons are shared in a double bond?
a. 1
b. 2
c. 4
d. 8

47. A compound forms between atoms of an element having 3 bonding p orbitals and atoms of an element having 1 bonding s orbital. The shape of the compound most closely resembles:
a. a straight line
b. a triangle
c. a pyramid
d. a square.

48. Given the orbital electron configuration of element T, predict what kind of bond will form between T-T.

Electron configuration:



a. single bond
b. ionic bond
c. double bond
d. triple bond

49. Which statement best expresses the relationship between the electronegativity of an element and the position of the element in the periodic table? Elements with the highest electronegativity:
    a. are in the groups near the center of the periodic table.
    b. are all in the same period.
    c. are on the left side of the periodic table.
    d. are on the right side of the periodic table.

50. Electronegativity is:
    a. a measure of the tendency of an atom to attract a shared pair of electrons to itself.
    b. the energy required to remove an electron from an atom.
    c. a measure of the tendency of an atom to become neutral.
    d. the energy required to form a molecule.

ACHIEVEMENT TEST II

Part I

1. When the equation ___$KClO_3$ → ___KCl + ___O_2 is balanced, the coefficients in front of the compounds from left to right are:
   a. 1, 1, 3
   b. 2, 2, 3
   c. 2, 3, 2
   d. 2, 1, 3

2. You have 23 grams of a substance whose molecular weight is 166 grams per mole. How many moles of this substance do you have?
   a. 7.2
   b. 3818
   c. 0.14
   d. 23

3. You have to weigh out 0.78 mole of a substance whose molecular weight is 46.8 grams/mole. How many grams is this?
   a. 36.5
   b. 60.0
   c. 0.0167
   d. 0.78

4. What is the molecular weight of $Pb(NO_3)_2$? The atomic weight of Pb is 207.2, N is 14.0 and O is 16.0.
   a. 269.2
   b. 538.4
   c. 207.2
   d. 331.2

5. If you mix 85 grams of $AgNO_3$ (MW=170) with 194 grams of K_2CrO_4 (MW=194.0) how many grams of Ag_2CrO_4 (MW=332) will be formed?
   a. 179 grams
   b. 83 grams
   c. 166 grams
   d. 332 grams

6. Magnesium (24.3 g/mole) is oxidized completely by oxygen according to the equation $2Mg + O_2 \rightarrow 2MgO$. If you start with 24.3 grams of Magnesium and all the oxygen that you need, how many grams of MgO will be formed?
   a. 32.3
   b. 80.6
   c. 40.3
   d. 24.3

7. In the reaction $2Fe + 3CuSO_4 = Fe_2(SO_4)_3 + 3Cu$, the material that is oxidized is:
   a. Fe
   b. $CuSO_4$
   c. Cu
   d. $Fe_2(SO_4)_3$

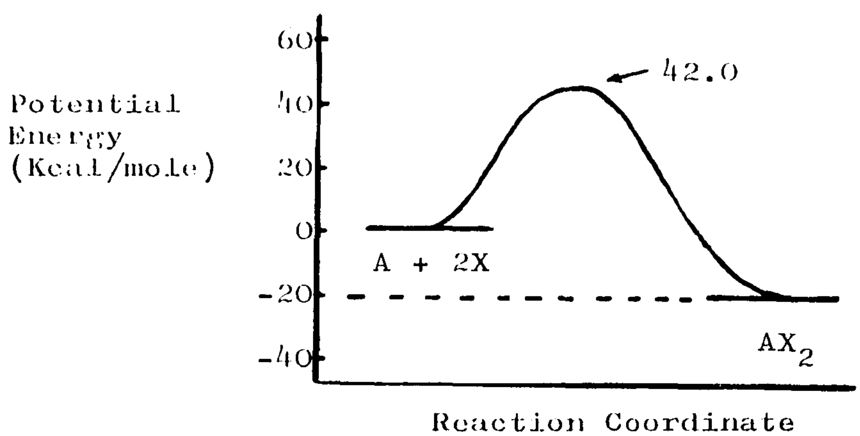
8. The oxidizing agent in the reaction shown in #7 is:
   a. Fe
   b. Fe^{+3}
   c. Cu
   d. Cu^{+2}

9. Raising the temperature of a reacting system increases the rate of reaction, but does not increase the:
   a. activation energy.
   b. number of collisions of molecules.
   c. number of reacting molecules with energy greater than the activation energy.
   d. speed of the reacting molecules.

10. In a chemical reaction, equilibrium is established when:
   a. no reaction is occurring.
   b. there is no net change in the concentration of reactants and products.
   c. the concentration of reactants and products is equal.
   d. the rate of formation of products is twice the rate of formation of reactants.

11. A catalyst:
   a. increases the rate at which chemical equilibrium is reached.
   b. raises the activation energy for a reaction.
   c. increases the amount of product in a reaction.
   d. increases the amount of reactants in a reaction.

Questions 12 and 13 refer to the following diagram.



12. For the reaction $AX_2 \rightarrow A + 2X$, what is the value of the activation energy?
    a. -20 kcal
    b. +42.0 kcal
    c. +62.0 kcal
    d 0.0 kcal

13. Which of the following statements is true concerning the energy of the reactants and products for the reaction $A + 2X = AX_2$?
    a. The reaction is endothermic.
    b. The net energy difference between reactants and products is 62 kcal.
    c. The net energy difference between reactants and products is 20 kcal.
    d. The net energy difference between reactants and products is the same as the activation energy for the forward reaction.

14. Increasing the concentration of reactants in a reaction mixture has what effect on the rate of that reaction?
    a. It decreases the rate of the reaction because the larger number of molecules make things proceed more slowly.
    b. It increases the rate because there is a greater chance of molecules colliding and reacting.
    c. It has no effect because the rate of a reaction is always constant.
    d. It has no effect because only temperature changes can affect reaction rate.

15. If the equilibrium concentrations for the reaction $H_2 + I_2 = 2HI$ are H_2=0.5 moles/liter, I_2=0.01 moles/liter and HI=0.5 moles/liter, what is the value of the equilibrium constant for this reaction?
    a. 50
    b. 100
    c. 1
    d. 5000

16. Which of the following is an example of a steady state situation?
    a. Water is running into a sink at the same rate that the water is leaving through a drain. The level of the water remains constant.
    b. A drop of water is in an air-filled balloon. Molecules of water are entering and leaving the liquid phase at the same rate.
    c. A chemical reaction is occurring in the forward and reverse directions at the same rate.
    d. One book is placed on top of another book which is on a flat surface.

17. How many grams of H_2SO_4 (MW=98) are there in 500ml of a 3M aqueous solution?
 a. 1500 grams
 b. 147 grams
 c. 294 grams
 d. none of these

18. How many grams of K_3PO_4 (MW=212) would you use to prepare 600ml of a 2M solution?
 a. 424 grams
 b. 254 grams
 c. 127 grams
 d. none of these

19. A solution in which the dissolved solute exists in a state of equilibrium with the undissolved solute is said to be:
 a. dilute
 b. concentrated
 c. saturated
 d. supersaturated

20. What is the molarity of 40ml of a solution of HCl (MW=36.5) which contains 3.65 grams of dissolved solute?
 a. 10.00 M
 b. 3.65 M
 c. 2.50 M
 d. 1.46 M

21. A solution is made by mixing 5 grams of $AgNO_3$ with enough water to give 400ml of total solution. What is the percent concentration of that solution?
 a. 5.00%
 b. 20.00%
 c. 2.50%
 d. 1.25%

22. A colloid which contains a liquid dispersed throughout another liquid is called:
 a. an emulsion
 b. a gel
 c. a sol
 d. an aerosol

23. Substances that dissolve in water to give solutions that conduct electricity are called:
 a. solutes
 b. electrolytes
 c. conductors
 d. ions

24. A homogeneous mixture of more than one material is called a:
   a. solvent
   b. colloid
   c. mixture
   d. solution

25. The bicarbonate ion (HCO_3^-) in aqueous solution may act as either an acid or a base. An equation for a reaction in which it is acting as an acid is:

   a. $HCO_3^- + H_2O = H_2CO_3 + OH^-$

   b. $HCO_3^- + H_2O = CO_3^{-2} + H_3O^+$

   c. $HCO_3^- + H_3O^+ = CO_2 + 2\ H_2O$

   d. $HCO_3^- + OH^- = H_2CO_3 + O^{-2}$

26. The statement which best describes the relationship between the strength of an acid and the size of the dissociation constant is:
   a. The smaller the dissociation constant, the stronger the acid.
   b. The larger the dissociation constant, the stronger the acid.
   c. There is no relationship between acid strength and dissociation constant because acids do not dissociate.
   d. There is no relationship between acid strength and dissociation constant because dissociation constants are not used to describe the dissociation of an acid.

27. In the reaction $CH_3COO^- + H_2O = CH_3COOH + OH^-$, which of the following is FALSE?
   a. CH_3COO^- is a base because it accepts a proton.
   b. CH_3COOH is an acid because it donates a proton.
   c. OH^- is a base because it accepts a proton.
   d. H_2O is a base because it accepts a proton.

28. For the dissociation $CH_3COOH = CH_3COO^- + H^+$, what is the effect of adding more CH_3COO^- ions?
   a. The concentration of CH_3COOH goes up and the concentration of H^+ goes down.
   b. The concentration of CH_3COOH goes down and the concentration of H^+ goes up.
   c. The concentration of both H^+ and CH_3COOH go up.
   d. This has no effect on the concentration of any of the materials. They must stay constant.

29. When HCl is added to pure water which of the following is true?
    a. The concentration of H^+ stays constant but the concentration of OH^- decreases.
    b. The concentration of H^+ goes up but the concentration of OH^- stays the same.
    c. The concentration of H^+ goes up and the concentration of OH^- goes down.
    d. The concentration of both of these ions always stays constant.

30. Water is a very weak electrolyte. Which of these statements is NOT TRUE about this weak electrolyte?
    a. Both hydronium and hydroxyl ions are always present in water.
    b. Water can act as either an acid or a base.
    c. Water is an excellent conductor of electricity.
    d. In pure water $[H_3O^+] = [OH^-]$

31. Choose the FALSE statement concerning acid strength:
    a. A strong acid is always more concentrated than a weak acid.
    b. A strong acid dissociates to a greater extent than a weak acid.
    c. The dissociation constant for a weak acid is always less than that of a strong acid.
    d. One liter of a 1N solution of a strong acid has more hydrogen ions than one liter of a 1N solution of a weak acid.

32. If HCl is added to the carbonic acid-sodium bicarbonate buffer system, the system resists changes in pH because:
    a. the chloride ions from HCl combine with the sodium ions from sodium bicarbonate to form NaCl.
    b. the hydrogen ions combine with the bicarbonate ion (HCO_3^-) to form the weak acid (H_2CO_3) which dissociates to a smaller degree than HCl.
    c. the H^+ ions combine with water molecules to form H_3O^+.
    d. the chloride ions combine with the carbonic acid.

Part 2

33. The oxidation number of chromium in $K_2Cr_2O_7$ is:
    a. +5
    b. -3
    c. +6
    d. +2

34. The oxidation potential for Zn is +0.76 and the oxidation potential for Cu is -0.34. In the oxidation-reduction reaction $Zn + Cu^{+2} = Cu + Zn^{+2}$, which way are electrons transferred?
a. From Cu to Zn^{+2}
b. From Zn to Cu
c. From Zn to Cu^{+2}
d. From Zn^{+2} to Zn

35. The equation $\underline{\quad}MnO_2 + \underline{\quad}NaCl + \underline{\quad}H_2SO_4 \rightarrow \underline{\quad}MnSO_4 + \underline{\quad}NaHSO_4 + \underline{\quad}H_2O + \underline{\quad}Cl_2$ can be balanced by the technique of using oxidation numbers. When the equation is balanced, the coefficient in front of H_2SO_4 is:
a. 1
b. 2
c. 3
d. 4

36. The reaction $H_2O_2 + I^- + H^+ = H_2O + I_2$ can be balanced by using half reactions. The half reactions are:

$$2I^- \longrightarrow I_2 + 2e^-$$

$$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$$

When the equation is balanced, the coefficient in front of H_2O is:

a. 1
b. 2
c. 3
d. 4

37. In the oxidation-reduction reaction $KOH + Cl_2 \rightarrow KClO_3 + KCl + H_2O$, which of the atoms take part in either an oxidation or a reduction?
a. K, O, Cl and H
b. K, O, and Cl
c. K and Cl
d. Cl

38. The equilibrium constant for a reaction is affected by a:
a. change in temperature.
b. change in concentration of reactants.
c. catalyst.
d. change in the concentration of products.

39. For the reaction $2H_2 + O_2 = 2H_2O$, the rate of the reaction in the forward direction is equal to:
a. $k [H_2] [O_2]$
b. $[H_2O]^2 / [H_2]^2 [O_2]$

c. $k [H_2]^2 [O_2]$
d. $[H_2O]^2 / [H_2]^2 + [O_2]$

40. At 490 degrees C, the equilibrium constant for $H_2 + I_2 = 2HI$ is 45.9. If 1 mole of H_2 and 1 mole of I_2 are introduced into a 1 liter container, the equilibrium concentration of H_2 will be:
a. 2 M
b. 0.77 M
c. 0.23 M
d. 1.00 M

41. Using the information in number 40 above, what will be the equilibrium concentration of HI?
a. 0.23 M
b. 1.54 M
c. 0.80 M
d. 2.00 M

42. $AgNO_3$ dissolves in water to give Ag^+ and NO_3^-. The solubility product expression for this solution is:
a. $K_{sp} = [Ag^+][NO_3^-] / [AgNO_3]$
b. $K_{sp} = [Ag^+][NO_3^-]$
c. $K_{sp} = [Ag^+] + [NO_3^-]$
d. $K_{sp} = \frac{[Ag^+] + [NO_3^-]}{[AgNO_3]}$

43. If Ag^+ ions and I^- ions are added to water, a precipitate of AgI will form when:
a. $[Ag^+][I^-] / [AgI] = K_{eq}$
b. $[Ag^+][I^-]$ is less than K_{sp}
c. $[Ag^+][I^-]$ is greater than K_{sp}
d. $[AgI] = K_{eq}$

44. The solubility product of $PbCrO_4$ is about 2×10^{-16}. What is the concentration of Pb^{+2} ions that are present at equilibrium?
a. 1.4×10^{-8} M
b. 2.0×10^{-16} M
c. 1.0×10^{-16} M
d. 4.0×10^{-8} M

45. 500 ml of a 10^{-7} M solution of AgCl is added to 500 ml of a 10^{-7} M solution of CuI. Which of the following is true?

a. A precipitate of $CuCl_2$ will form. ($K_{sp} = 3.2 \times 10^{-7}$)

b. A precipitate of AgI will form. ($K_{sp} = 1.0 \times 10^{-17}$)

c. No precipitate will form.
d. Both $CuCl_2$ and AgI will precipitate.

46. The pH of a 0.0001 M aqueous HCl solution is:
a. 0.0001
b. 1
c. 10^{-4}
d. 4

47. The pH of a solution whose H^+ concentration is 3.2×10^{-4} is approximately:
a. 1
b. -4
c. 12
d. 4

48. The hydrogen ion concentration of a solution is 2.0×10^{-2} M. The pH of that solution is:
a. 2
b. 1.7
c. 2.3
d. 4

49. What is the hydrogen ion concentration at equilibrium of one liter of a solution which is made with water and 1 mole of acetic acid? K_a for acetic acid equals 1.8×10^{-5}. ($CH_3COOH = CH_3COO^- + H^+$)

a. 6.0×10^{-3} M

b. 4.25×10^{-3} M

c. 1.8×10^{-5} M

d. 3.6×10^{-5} M

50. Calculate the pH of a buffered system that contains 2 moles of carbonic acid and 4 moles of sodium bicarbonate in 1 liter of solution. $K_a = 4.4 \times 10^{-7}$ for the dissociation of H_2CO_3. ($pK_a = 6.36$)

a. 2.00
b. 7.42
c. 6.36
d. 6.66

Final Examination

Section A Units VIII - XI

Part 1

1. Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules is a statement of:

   a. The Kinetic Theory
   b. Charles' Law
   c. Avagadro's Hypothesis
   d. Dalton's Law

2. Absolute zero is the same as:

   a. 0 degrees Centigrade
   b. 273 degrees Kelvin
   c. -273 degrees Kelvin
   d. -273 degrees Centigrade

3. The volume occupied by a mole of any gas at standard temperature and pressure is:

   a. different for each gas
   b. 22.4 liters
   c. 1 liter
   d. 6.02×10^{23} liters

4. Two gases are placed together in a flask. The total pressure exerted by the two gases is 100 mm Hg. One of the gases exerts a pressure of 40 mm. What is the partial pressure of the second gas?

   a. 60 mm
   b. 90 mm
   c. 40/100 mm
   d. 100/40 mm

5. Standard temperature and Pressure is:

   a. 0 degrees Centigrade and 700 mm Hg
   b. 0 degrees Kelvin and 760 mm Hg
   c. 0 degrees Centigrade and 760 mm Hg
   d. 273 degrees Kelvin and 700 mm Hg

6. To change a gas volume of 640 ml to 160 ml at constant temperature requires that the pressure be:

   a. kept constant
   b. doubled
   c. tripled
   d. quadrupled

7. A sample of gas has a volume of 700 ml at 600 mm Hg pressure and a temperature of 60 degrees Centigrade. The volume that this gas occupies at 400 mm Hg pressure and 30 degrees Centigrade is:

a. 425 ml
b. 513 ml
c. 955 ml
d. 1155 ml

8. A gas has a volume of 800 ml at 700 mm Hg pressure and a temperature of 40 degrees Centigrade. The volume that this gas occupies at STP is:

a. 756 ml
b. 642 ml
c. 321 ml
d. 960 ml

9. Which of the following should be classified as an unsaturated hydrocarbon?

a. alkane
b. alkene
c. alcohol
d. amine

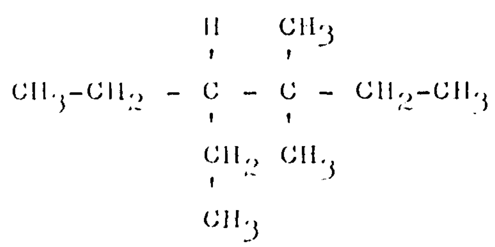
10. The name of the alkane having the structure $CH_3CH_2CH_2CH_3$ is:

a. propane
b. butane
c. ethane
d. hexane

11. The name of the organic radical having the formula CH_3CH_2- is:

a. ethane
b. methyl
c. ethyl
d. propane

12. What is the name of the organic compound pictured below:



a. 3,3-dimethyl-4-ethylhexane
b. 2-methyl-2,4-diethylpentane
c. 4,4-dimethyl-3-ethylhexane
d. 3-methyl-4-ethylheptane

13. The name of the organic compound pictured below is:

$$CH_3CH_2CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_2CH_2CH_3$$

a. 4-methylnonane
b. 4-ethyloctane
c. 5-methyloctane
d. 4-methyloctane

14. The name of the family of organic compounds having the functional group $\left[\begin{array}{c} O \\ \| \\ -C-H \end{array}\right]$ is:

a. alcohol
b. acid
c. ketone
d. aldehyde

15. What family is this organic compound in? $CH_3CH_2CH_2CH_2CH_2OH$

a. amine
b. alcohol
c. ketone
d. acid

16. Carbon, when bonded to four other atoms, has four equivalent sp^3 bonding orbitals. Which of the following words best describes the shape of the bonding arrangement around carbon?

a. square
b. triangular
c. rectangular
d. tetrahedral

17. Carboxylic acids are classified as acids because they:

a. give up electrons to other atoms.
b. donate hydrogen atoms to other atoms.
c. are caustic.
d. accept hydrogen atoms from other atoms.

18. In the following acid-base reaction, identify the substances that are acting as acids:

$$\underset{I}{CH_3CH_2NH_3^+} + \underset{II}{H_2O} = \underset{III}{CH_3CH_2NH_2} + \underset{IV}{H_3O^+}$$

a. Substances I and II
b. Substance IV
c. Substances I and IV
d. Substances II and III

19. Carbonic acid is considered to be a weak inorganic acid. The strength of organic acids is best described as:

a. very strong
b. strong
c. weak
d. very weak

20. For the oxidation-reduction reaction:

$$CH_3CH_2\overset{O}{\overset{\|}{C}}H + H_2O + 2\ Cu^{+2} = CH_3CH_2COOH + 2H^+ + 2Cu^+,$$

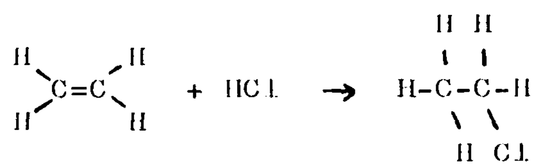
what is being oxidized in the forward reaction?

a. $CH_3CH_2\overset{O}{\overset{\|}{C}}H$
b. CH_3CH_2COOH
c. Cu^+
d. Cu^{+2}

21. For the reaction shown in question 20, what is the oxidizing agent?

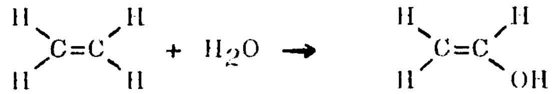
a. $CH_3CH_2\overset{O}{\overset{\|}{C}}H$
b. CH_3CH_2COOH
c. Cu^+
d. Cu^{+2}

22. Which of the following is an example of a material being "added across a double bond"?

a. 

b. $CH_3CH_3 + HCl \rightarrow CH_4CH_2Cl$

c. $CH_3CH_3 + H_2O \rightarrow CH_3CH_2OH$

d. 

23. Which of the following is not a valid explanation for the unreactivity of alkanes?

a. The bonds in alkanes are non-polar.
b. The valence shells in alkanes are filled.
c. Carbon is present in alkanes.
d. There are no charges present on alkanes.

24. Alcohols can be oxidized to aldehydes by means of an oxidizing agent such as potassium dichromate.

$\_\_CH_3CH_2OH + \_\_Cr_2O_7^{-2} + \_\_H^+ \longrightarrow \_\_CH_3CHO + \_\_Cr^{+3} + \_\_H_2O$

The reaction can be balanced by using the following half reactions:

Reduction: $Cr_2O_7^{-2} + 14\ H^+ + 6\ e^- \longrightarrow 2\ Cr^{+3} + 7\ H_2O$

Oxidation: $CH_3CH_2OH \longrightarrow CH_3CHO + 2H^+ + 2\ e^-$

When the reaction is balanced, the coefficient in front of CH_3CH_2OH is:

a. 1
b. 2
c. 3
d. 4

25. Which of the following is not a characteristic of alpha particles?

a. very penetrating
b. same as helium nucleus
c. have a mass of 4 units
d. easily stopped by air molecules

26. Which statement below is not true of gamma rays:

a. very penetrating
b. pure electromagnetic energy
c. have ability to destroy tissue
d. same as fast moving electron

27. Carbon-14, which has an atomic number of 6, is neutron rich. It decays by beta decay to yield:

a. Carbon-12
<u>b</u>. Nitrogen-14
c. Carbon-13
d. Nitrogen-15

28. A neutron-rich radioactive element will disintegrate in such a way that results in the formation of an element whose:

<u>a</u>. atomic number is increased by one, but whose mass number is unchanged.
b. mass number is decreased by one but whose atomic number is unchanged.
c. atomic number is decreased by one but whose mass number is unchanged.
d. mass number is increased by one but whose atomic number is unchanged.

29. When a nucleus undergoes K capture which of the following changes takes place?

<u>a</u>. atomic number decreases by one.
b. mass number and atomic number decrease by one.
c. atomic number increases by one.
d. atomic number and mass number increase by one.

30. Nuclei which have an atomic number greater than 83 disintegrate by:

a. K capture
b. beta decay
<u>c</u>. emission of alpha particles
d. emission of protons

31. Choose the best statement about radioactivity:

a. Radioactivity can occur in all nuclei no matter what their composition is.
<u>b</u>. In a sense, radioactivity is a tendency to achieve a neutron to proton ratio which is on "the line of nuclear stability."
c. Radioactivity is a tendency to achieve a nuclear arrangement in which the number of protons and number of neutrons is equal.
d. Radioactivity occurs in all nuclei having an atomic number less than 83.

32. Choose the correct statement about the danger of gamma rays to living tissues:

   a. Gamma rays are not dangerous because they have no mass.
   b. Gamma rays are very dangerous because they can knock electrons out of their orbitals.
   c. Gamma rays are dangerous because they have a relatively large mass and high velocity which allows them to destroy tissue on impact.
   d. When compared to alpha and beta particles, gamma rays are only slightly dangerous.

Part 2

33. Use the equation of state to calculate the pressure exerted by 1 mole of NH_3 at 27°C in a volume of 4 liters. $R = 0.0820 \frac{\text{atmospheres}\cdot\text{liters}}{\text{moles}\cdot\text{degrees}}$

   a. 0.57 atm.
   b. 4.00 atm.
   c. 6.15 atm.
   d. 22.4 atm.

34. Calculate the number of moles of a gas present in a 3 liter container which exerts a pressure of 5 atmospheres at 77°C.

   a. 0.52 moles
   b. 1.36 moles
   c. 15.00 moles
   d. 2.37 moles

35. Use the information in question 34 to calculate the approximate molecular weight of this gas. You also have the additional information that the gas sample weighs 13.5 grams.

   a. MW = 26
   b. MW = 10
   c. MW = 2
   d. MW = 55

36. Arrange this group of gases according to the rate at which they diffuse. The slowest gas should be first and the fastest gas last.
(H_2 MW=2, NH_3 MW=17, HCl MW=36.5, O_2 MW=32)

a. H_2, NH_3, O_2, HCl

b. NH_3, HCl, NH_3, H_2

c. HCl, NH_3, H_2, O_2

d. HCl, O_2, NH_3, H_2

37. Name this compound by the IUPAC naming system:

$$\begin{array}{c} \quad CH_3 \qquad\quad OH \\ CH_3\text{-}\underset{}{CH}\text{-}CH_2\text{-}CH\text{-}CH_2\text{-}CH_3 \end{array}$$

a. 5-methyl-3-heptanol
b. 5-methyl-3-hexanol
c. 2-methyl-3-hexanone
d. 2-methyl-5-hexanal

38. Name by the IUPAC naming system this compound:

$$\begin{array}{c} \qquad\qquad\qquad CH_3 \\ CH_3\text{-}CH_2\text{-}CH_2\text{-}CH\text{-}CH\text{-}CH_2\text{-}COOH \\ CH_3 \end{array}$$

a. 3,4-dimethylheptanoic acid
b. 4,5-dimethylheptanoic acid
c. 3,4-dimethylheptanone
d. 2,2-dimethylheptanone

39. Name this compound by the IUPAC naming system:

$$\begin{array}{c} \qquad\qquad\qquad O \\ \qquad\qquad\qquad \| \\ CH_3CH_2\text{-}CH\text{-}CH_2\text{-}C\text{-}H \\ CH_2\text{-}CH_3 \end{array}$$

a. 3-ethylpentanoic acid
b. 3-ethylpentanal
c. 3,3-diethylpentanal
d. 3-methylhexanone

40. What is the common name of this compound?

$$\begin{array}{c} O \\ \| \\ CH_3\text{-}C\text{-}CH_2CH_3 \end{array}$$

a. propionic acid
b. 2-oxybutane
c. methyl ethyl ketone
d. 2-butanone

41. What is the common name of this compound?

$$\mathrm{H-\overset{O}{\overset{\|}{C}}-H}$$

a. acetone
b. dihydrogen carboxide
c. formaldehyde
d. acetic acid

42. Identify the type of this reaction:

$$\mathrm{CH_3CH_2CH_2-OH + CH_3-CH_2-COOH \longrightarrow H_2O + CH_3-CH_2-\overset{O}{\overset{\|}{C}}-O-CH_2-CH_2-CH_3}$$

a. condensation
b. condensation polymerization
c. hydrolysis
d. addition polymerization

43. Identify the type of this reaction:

$$\mathrm{CH_3-\overset{O}{\overset{\|}{C}}-O-CH_2-CH_3 + H_2O \longrightarrow CH_3CH_2-OH + CH_3-COOH}$$

a. condensation
b. condensation polymerization
c. hydrolysis
d. addition polymerization

44. The term monomer refers to:

a. the repeating subunits which make up a polymer.
b. molecules composed of only one atom.
c. the parent compound of a large organic molecule upon which the name of the compound is derived.
d. functional groups composed of only one atom.

45. When an ester (RCOOR) is split by water to yield an alcohol and an acid, the type of reaction is called:

a. addition
b. condensation
c. elimination
d. hydrolysis

46. The term half-life refers to:

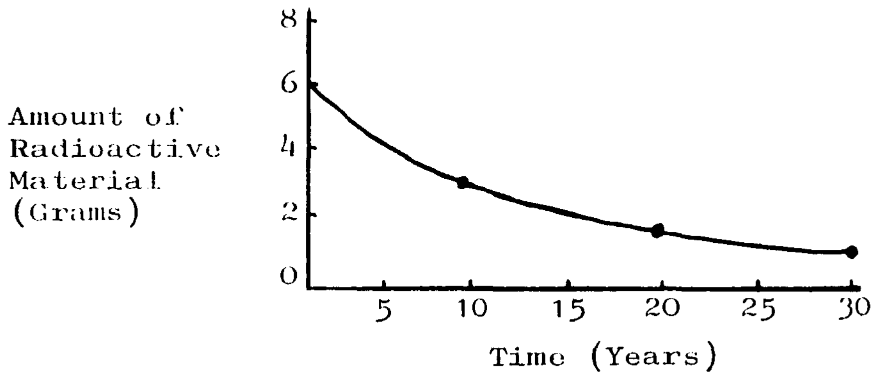
a. half the time needed for a radioactive sample to disintegrate.
b. the time needed for half the weight of a radioactive sample to disintegrate.

c. half of the time needed for half of the weight of a radioactive sample to disintegrate.
d. half the time needed for a radioactive sample to disintegrate divided by two.

47. The half-life of a certain radioactive material is 2 years. Of 8 grams of a sample of this radioactive material which existed 10 years ago, how much is still radioactive today?

<u>a</u>. 1/4 gram
b. 1/2 gram
c. 0 grams
d. 4 grams

48.



What is the half-life of the radioactive material whose decay is shown on the graph above?

a. 5 years
<u>b</u>. 10 years
c. 15 years
d. 30 years

49. Choose the nuclear reaction which does <u>not</u> demonstrate the conservation of mass.

a. ${}_7N^{14} + {}_2He^4 \longrightarrow {}_1H^1 + {}_8O^{17}$

b. ${}_4Be^9 + {}_2He^4 \longrightarrow {}_6C^{12} + {}_0n^1$

c. ${}_5B^{10} + {}_2He^4 \longrightarrow {}_7N^{13} + {}_0n^1$

<u>d</u>. ${}_6C^{12} + {}_2He^4 \longrightarrow {}_7N^{14} + {}_0n^1$

50. The term nucleon refers to:

   a. neutrons and protons in a nucleus.
   b. subatomic particles in the nucleus other than protons and neutrons.
   c. subatomic particles outside the nucleus.
   d. the helium nucleus.

Section B - Units I - VII

Part I

1. The total number of protons and neutrons in an atom is equivalent to its:

   a. atomic number
   b. atomic weight
   c. mass number
   d. molecular weight

2. The number of electrons that can be present in the second principle energy level of an atom is:

   a. 2
   b. 6
   c. 8
   d. 18

3. An atom has six electrons, six protons and six neutrons. Its mass number is:

   a. 6
   b. 12
   c. 18
   d. 32

4. An atom which has lost three electrons has a charge of:

   a. -3
   b. +3
   c. 0
   d. The charge cannot be determined from this information.

5. The nucleus of an atom having atomic number 7 and mass number 14 contains:

   a. 7 electrons and 7 protons
   b. 14 protons and 7 neutrons
   c. 14 neutrons
   d. 7 protons and 7 neutrons

6. The total number of protons in an atom is equivalent to its:

   a. atomic number
   b. atomic weight
   c. mass number
   d. molecular weight

7. The Group IIA elements have how many electrons in their outer shell?

   a. 1
   b. 2
   c. 6
   d. It varies for each element in this group.

8. Elements in the third period of the periodic table have how many electrons in their outer shell?

   a. 2
   b. 3
   c. 5
   d. It varies for each element in this period.

9. Which statement best expresses the relationship between atomic structure and periodically recurring properties?

   a. Elements which have the same number of electrons in their first and second shells have similar properties.
   b. Elements which have the same number of electrons in their first shell only, have similar properties.
   c. Elements which have similar atomic structure have similar properties.
   d. There is no relationship.

10. As one proceeds from left to right in a period of the periodic table:

   a. each atom has one more neutron than the atom preceding it.
   b. the atoms become more highly charged.
   c. the properties of these elements are very similar.
   d. every atom has one more electron and one more proton than the atom preceding it.

11. An element with atomic number 20 is in:

   a. period 2
   b. period 3
   c. period 4
   d. period 5

12. The elements having the highest ionization energy are found:

 a. in the first group of the periodic table.
 b. in the fourth period of the periodic table.
 c. on the left side of the periodic table.
 d. on the right side of the periodic table.

13. Lithium has one valence electron and chlorine has seven valence electrons. Which of these compounds would be most likely to form?

 a. LiCl
 b. $LiCl_2$
 c. $LiCl_7$
 d. Li_7Cl

14. In a covalent bond:

 a. there is an attraction between oppositely charged ions.
 b. a pair of electrons is shared by two atoms.
 c. electrons are not attached to any atoms but are moving freely among all the atoms.
 d. protons are lost from one atom and gained by another.

15. A negative ion is formed when:

 a. electrons are removed from a neutral atom.
 b. electrons are added to a neutral atom.
 c. a covalent bond joins two atoms.
 d. a molecule is formed.

16. When a molecule forms:

 a. the molecule has a lower energy value than the atoms which make it up.
 b. the molecule has a higher energy value than the atoms which make it up.
 c. the molecule has the same energy value as the atoms which make it up.
 d. This cannot be determined. It varies for each molecule.

17. If you mix 85 grams of $AgNO_3$ (MW=170) with 194 grams of K_2CrO_4 (MW=194.0) how many grams of Ag_2CrO_4 will be formed?

 a. 179 grams
 b. 83 grams
 c. 166 grams
 d. 332 grams

18. Magnesium (24.3 grams/mole) is oxidized completely by oxygen according to the equation $2Mg + O_2 \rightarrow 2MgO$. If you start with 24.3 grams of Magnesium and all the oxygen that you need, how many grams of MgO will be formed?

a. 32.3
b. 80.6
c. 40.3
d. 24.3

19. In the reaction $2Fe + 3CuSO_4 = Fe_2(SO_4)_3 + 3Cu$, the material that is oxidized is:

a. Fe
b. $CuSO_4$
c. Cu
d. $Fe_2(SO_4)_3$

20. The oxidizing agent in the reaction shown in #19 above is:

a. Fe
b. Fe^{+3}
c. Cu
d. Cu^{+2}

21. Raising the temperature of a reacting system increases the rate of reaction, but does not increase the:

a. activation energy
b. number of collisions of molecules.
c. number of reacting molecules with energy greater than the activation energy.
d. speed of the reacting molecules.

22. In a chemical reaction, equilibrium is established when:

a. no reaction is occurring.
b. there is no net change in the concentration of reactants and products.
c. the concentration of reactants and products is equal.
d. the rate of formation of products is twice the rate of formation of reactants.

23. Increasing the concentration of reactants in a reaction mixture has what effect on the rate of that reaction?

a. It decreases the rate of the reaction because the larger number of molecules make things proceed more slowly.

b. It increases the rate because there is a greater chance of molecules colliding and reacting.
c. It has no effect because the rate of a reaction is always constant.
d. It has no effect because only temperature changes can affect reaction rate.

24. Which of the following is an example of a steady state situation?

a. Water is running into a sink at the same rate that the water is leaving through a drain. The level of the water remains constant.
b. A drop of water is in an air-filled balloon. Molecules of water are entering and leaving the liquid phase at the same rate.
c. A chemical reaction is occurring in the forward and reverse directions at the same rate.
d. One book is placed on top of another book which is on a flat surface.

25. How many grams of H_2SO_4 (MW=98) are there in 500 ml of a 3M aqueous solution?

a. 1500 grams
b. 147 grams
c. 294 grams
d. none of these

26. A solution in which the dissolved solute exists in a state of equilibrium with the undissolved solute is said to be:

a. dilute
b. concentrated
c. saturated
d. supersaturated

27. A colloid which contains a liquid dispersed throughout another liquid is called:

a. an emulsion
b. a gel
c. a sol
d. an aerosol

28. Substances that dissolve in water to give solutions that conduct electricity are called:

a. solutes
b. electrolytes
c. conductors
d. ions

29. The statement which best describes the relationship between the strength of an acid and the size of the dissociation constant is:

    a. The smaller the dissociation constant, the stronger the acid.
    b. The larger the dissociation constant, the stronger the acid.
    c. There is no relationship between acid strength and dissociation constant because acids do not dissociate.
    d. There is no relationship between acid strength and dissociation constant because dissociation constants are not used to describe the dissociation of an acid.

30. For the dissociation $CH_3COOH = CH_3COO^- + H^+$, what is the effect of adding more CH_3COO^- ions?

    a. The concentration of CH_3COOH goes up and the concentration of H^+ goes down.
    b. The concentration of CH_3COOH goes down and the concentration of H^+ goes up.
    c. The concentration of both H^+ and CH_3COOH go up.
    d. This has no effect on the concentration of any of the materials. They must stay constant.

31. Water is a very weak electrolyte. Which of these statements is NOT true about this weak electrolyte?

    a. Both hydronium and hydroxyl ions are always present in water.
    b. Water can act as either an acid or a base.
    c. Water is an excellent conductor of electricity.
    d. In pure water $[H_3O^+] = [OH^-]$

32. When HCl is added to pure water which of the following is true?

    a. The concentration of H^+ goes up but the concentration of OH^- stays the same.
    b. The concentration of H^+ stays constant but the concentration of OH^- decreases.
    c. The concentration of H^+ goes up and the concentration of OH^- goes down.
    d. The concentration of both of these ions always stays constant.

Part 2

33. A spherical orbital which contains two electrons is a/an ______ orbital.

a. s
b. p
c. d
d. f

34. The orbital electron configuration of carbon (atomic number 6) is correctly represented as:

	1s	2s	$2p_x$	$2p_y$	$2p_z$	3s
a.	↑↓	↑↓	↑	↑	○	○
b.	↑↓	↑↓	↑↓	○	○	○
c.	↑↓	↑	↑	↑	↑	○
d.	↑	↑	↑	↑	↑	↑

35. There is a kind of orbital which is shaped like a dumbell. There are three of these orbitals which are equivalent in energy. How many electrons can each of this kind of orbital hold?

a. 2
b. 3
c. 4
d. 6

36. Period 2 of the periodic table is the same as:

a. Group II
b. the very short series
c. the first short series
d. the second short series

37. How many clusters of orbitals having approximately the same energy are there for argon having atomic number 18, and how many orbitals are there in each cluster?

a. One cluster with nine orbitals.
b. Three clusters with 2, 8, and 8 orbitals in the three clusters.
c. Two clusters with 9 orbitals in each cluster.
d. Three clusters with 1, 4 and 4 orbitals in the three clusters.

38. Look at the following electron configurations and tell which elements have similar properties.

1. $1s^2\ 2s^2\ 2p^6\ 3s^1$
2. $1s^2\ 2s^2\ 2p^6\ 3s^2$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

a. 1 and 2
b. 1, 2, and 3
c. 2 and 4
d. 2, 3, and 4

39. Given that the electronegativity value of Li is 1.0, Cl is 3.0, H is 2.1 and F is 4.0, tell which of the following lists of compounds is arranged in order of increasing polarity.

a. LiH, HF, LiCl, LiF
b. LiF, LiCl, HF, LiH
c. LiH, LiF, LiCl, HF
d. HF, LiCl, LiH, LiF

40. A compound forms between atoms of an element having 3 bonding orbitals which are p orbitals, and atoms of an element having 1 bonding s orbital. The shape of the compound most closely resembles:

a. a straight line
b. a triangle
c. a pyramid
d. a square

41. Electronegativity is:

a. a measure of the tendency of an atom to attract a shared pair of electrons to itself.
b. the energy required to remove an electron from an atom.
c. a measure of the tendency of an atom to become neutral.
d. the energy required to form a molecule.

42. The oxidation number of chromium in $K_2Cr_2O_7$ is:

a. +5
b. -3
c. +6
d. +2

43. The equation __MnO_2 + __NaCl + __H_2SO_4 → __$MnSO_4$ + __$NaHSO_4$ + __H_2O + __Cl_2

can be balanced by the technique of using oxidation numbers. When the equation is balanced, the coefficient in front of H_2SO_4 is:

a. 1
b. 2
c. 3
d. 4

44. In the oxidation-reduction reaction $KOH + Cl_2 \rightarrow KClO_3 + KCl + H_2O$, which of the atoms take part in either an oxidation or a reduction?

a. K, O, Cl and H
b. K, O, and Cl
c. K and Cl
d. Cl

45. The equilibrium constant for a reaction is affected by a:

a. change in temperature.
b. change in the concentration of reactants.
c. catalyst.
d. change in the concentration of products.

46. For the reaction $2H_2 + O_2 = 2H_2O$, the rate of the reaction in the forward direction is equal to:

a. $k[H_2][O_2]$

b. $[H_2O]^2 / [H_2]^2[O_2]$

c. $k[H_2]^2[O_2]$

d. $[H_2O]^2 / [H_2]^2 + [O_2]$

47. If Ag^+ ions and I^- ions are added to water, a precipitate of AgI will form when:

a. $[Ag^+][I^-] / [AgI] = K_{eq}$

b. $[Ag^+][I^-]$ is less than K_{sp}

c. $[Ag^+][I^-]$ is greater than K_{sp}

d. $[AgI] = K_{eq}$

48. 500 ml of a 10^{-7} M solution of AgCl is added to 500 ml of a 10^{-7} M solution of CuI. Which of the following is true?

a. A precipitate of $CuCl_2$ will form. ($K_{sp}=3.2 \times 10^{-7}$)

b. A precipitate of AgI will form. ($K_{sp}=1.0 \times 10^{-17}$)

c. No precipitate will form.
d. Both $CuCl_2$ and AgI will precipitate.

49. The pH of a 0.0001 M aqueous HCl solution is:

a. 0.0001
b. 1
c. 10^{-4}
d. 4

50. What is the hydrogen ion concentration at equilibrium of one liter of a solution which is made with water and 1 mole of acetic acid? K_a for acetic acid equals 1.8 x 10^{-5}. ($CH_3COOH = CH_3COO^- + H^+$)

a. 6.0 x 10^{-3}M
b. 4.25 x 10^{-3}M
c. 1.8 x 10^{-5}M
d. 3.6 x 10^{-5}M

APPENDIX E

TESTS OF ASSUMPTIONS UNDERLYING ANALYSIS OF VARIANCE AND COVARIANCE

TABLE XXI

TEST FOR HOMOGENEITY OF VARIANCE OF INITIAL DATA FOR MEDICAL AND SURGICAL GROUPS

Variable	$F_{max}(2,38)$
SCAT Verbal	1.538
SCAT Quantitative	1.380
First Semester GPA	1.436
Chemistry Pretest	1.353
Attitude Pretest	1.111

Critical Region: $F_{max}(2,38)_{.05} > 1.97$

TABLE XXII

TEST FOR HOMOGENEITY OF VARIANCE OF ACHIEVEMENT TEST SCORES FOR MEDICAL AND SURGICAL GROUPS

Variable	F_{max} (2,38)
ACH Test I - Part 1	1.242
ACH Test I - Part 2	1.109
ACH Test II - Part 1	1.987*
ACH Test II - Part 2	2.129*
Final Exam	
Section A - Part 1	1.523
Section A - Part 2	1.301
Section B - Part 1	1.307
Section B - Part 2	1.743

Critical Region: $F_{max}(2,38)_{.05} > 1.97$

*Heterogeneous Variance

TABLE XXIII

TEST FOR HOMOGENEITY OF VARIANCE OF ATTITUDE DATA FOR MEDICAL AND SURGICAL GROUPS

Variable	$F_{max}(2,38)$
Attitude Pretest	1.111
Attitude Posttest	1.199
Film Attendance	2.295*
Weekly Study Time	1.211

Critical Region: $F_{max}(2,38)_{.05} > 1.97$

*Heterogeneous Variance

TABLE XXIV

TESTS OF ASSUMPTIONS UNDERLYING ANALYSIS OF COVARIANCE FOR CHEMISTRY PRETEST FOR MEDICAL AND SURGICAL GROUPS

	Hypotheses			
	$H_o: b_w = 0$		$H_o: b_1 = b_2$	
Variable	F(1,60)	p	F(1,59)	p
ACH Test I - Part 1	3.890	>0.05	0.517	>0.05
ACH Test I - Part 2	16.026	<0.05	0.068	>0.05
ACH Test II - Part 1	7.683	<0.05	3.164	>0.05
ACH Test II - Part 2	8.706	<0.05	0.844	>0.05
Final Exam				
Section A - Part 1	5.205	<0.05	1.784	>0.05
Section A - Part 2	8.801	<0.05	0.921	>0.05
Section B - Part 1	3.767	>0.05	1.502	>0.05
Section B - Part 2	9.606	<0.05	2.061	>0.05

$H_o: b_w = 0$ Critical Region: $F(1,60)_{.05} > 4.00$

$H_o: b_1 = b_2$ Critical Region: $F(1.59)_{.05} > 4.00$

$p < 0.05$ Reject the null hypothesis

$p > 0.05$ Fail to reject the null hypothesis

TABLE XXV

TESTS OF ASSUMPTIONS UNDERLYING ANALYSIS OF COVARIANCE FOR SCAT VERBAL FOR MEDICAL AND SURGICAL GROUPS

	Hypotheses			
	$H_o: b_w = 0$		$H_o: b_1 = b_2$	
Variable	F(1,60)	p	F(1,59)	p
ACH Test I - Part 1	0.406	>0.05	-	-
ACH Test I - Part 2	1.958	>0.05	-	-
ACH Test II - Part 1	3.220	>0.05	-	-
ACH Test II - Part 2	2.391	>0.05	-	-
Final Exam				
Section A - Part 1	2.365	>0.05	-	-
Section A - Part 2	4.423	<0.05	9.047	<0.05
Section B - Part 1	0.218	>0.05	-	-
Section B - Part 2	2.563	>0.05	-	-

$H_o: b_w = 0$ Critical Region: $F(1,60)_{.05} > 4.00$

$H_o: b_1 = b_2$ Critical Region: $F(1.59)_{.05} > 4.00$

$p < 0.05$ Reject the null hypothesis

$p > 0.05$ Fail to reject the null hypothesis

TABLE XXVI

TESTS OF ASSUMPTIONS UNDERLYING ANALYSIS OF COVARIANCE FOR SCAT QUANTITATIVE FOR MEDICAL AND SURGICAL GROUPS

	Hypotheses			
	$H_o: b_w = 0$		$H_o: b_1 = b_2$	
Variable	F(1,60)	p	F(1,59)	p
ACH Test I - Part 1	0.992	>0.05	-	-
ACH Test I - Part 2	2.499	>0.05	-	-
ACH Test II - Part 1	2.955	>0.05	-	-
ACH Test II - Part 2	4.083	<0.05	1.045	>0.05
Final Exam				
Section A - Part 1	0.236	>0.05	-	-
Section A - Part 2	4.215	<0.05	3.219	>0.05
Section B - Part 1	1.937	>0.05	-	-
Section B - Part 2	9.178	<0.05	0.623	>0.05

$H_o: b_w = 0$ Critical Region: $F(1,60)_{.05} > 4.00$

$H_o: b_1 = b_2$ Critical Region: $F(1,59)_{.05} > 4.00$

$p < 0.05$ Reject the null hypothesis

$p > 0.05$ Fail to reject the null hypothesis

TABLE XXVIII

TEST FOR HOMOGENEITY OF VARIANCE OF INITIAL DATA FOR TREATMENT AND CONTROL GROUPS

Variable	$F_{max}(2,32)$
SCAT Verbal	1.189
SCAT Quantitative	1.304
First Semester GPA	1.262
Chemistry Pretest	1.414
Attitude Pretest	2.490*

Critical Region: $F_{max}(2,32)_{.05} > 2.04$

*Heterogeneous Variance

TABLE XXVIII

TEST FOR HOMOGENEITY OF VARIANCE OF ACHIEVEMENT TEST SCORES OF TREATMENT AND CONTROL GROUPS

Variable	$F_{max}(2,32)$
ACH Test I - Part 1	1.135
ACH Test I - Part 2	1.281
ACH Test II - Part 1	1.385
ACH Test II - Part 2	1.906
Final Exam	
Section A - Part 1	1.292
Section A - Part 2	1.066
Section B - Part 1	1.110
Section B - Part 2	1.223

Critical Region: $F_{max}(2,32)_{.05} > 2.04$

TABLE XXIX

TEST FOR HOMOGENEITY OF VARIANCE OF ATTITUDE DATA FOR TREATMENT AND CONTROL GROUPS

Variable	$F_{max}(2,32)$
Attitude Pretest	2.490*
Attitude Posttest	1.148
Film Attendance	1.035
Weekly Study Time	1.174

Critical Region: $F_{max}(2,32)_{.05} > 2.04$

*Heterogeneous Variance

APPENDIX F

CORRELATIONS OF ALL DEPENDENT VARIABLES

TABLE XXX

CORRELATIONS OF ALL DEPENDENT VARIABLES

	ACH I-1	ACH I-2	ACH II-1	ACH II-2	FINAL A-1	FINAL A-2	FINAL B-1	FINAL B-2	ACH Tot.	ATTITUDE POSTTEST	FILMS
ACH I-2	.649										
ACH II-1	.683	.577									
ACH II-2	.445	.492	.635								
FINAL A-1	.651	.566	.745	.626							
FINAL A-2	.448	.584	.610	.540	.505						
FINAL B-1	.440	.287	.509	.489	.501	.398					
FINAL B-2	.624	.538	.617	.591	.548	.530	.620				
ACH Total	.794	.728	.884	.754	.845	.721	.699	.795			
ATTITUDE POSTTEST	.138	.051	.068	.016	.192	.038	-.022	.013	.086		
FILMS	.282	.007	.117	.001	.207	.011	-.017	.049	.117	.472	
STUDY TIME	-.014	-.177	.040	-.030	-.067	-.034	.118	-.043	-.019	.043	.204

APPENDIX G

SUMMARY OF DEPENDENT AND INDEPENDENT VARIABLES FOR CONTROL AND TREATMENT GROUPS

TABLE XXXI

SUMMARY OF DATA FOR CONTROL GROUP - DEPENDENT VARIABLES

				ACHIEVEMENT TESTS								
									Final Exam			
Ident. Number	Attitude Posttest	Films	Study Time	I-1	I-2	II-1	II-2	A-1	A-2	B-1	B-2	Total
2201	4.7	2	4.14	29	10	22	07	20	09	24	07	60
2202	4.7	1	3.00	21	10	09	03	16	03	28	06	53
2203	2.9	0	4.08	31	15	28	06	21	17	30	14	82
2204	2.8	0	0.18	30	16	25	10	23	10	26	07	66
2105	3.4	1	2.86	22	13	14	07	13	09	19	06	47
2106	7.1	4	3.18	29	14	18	05	22	08	21	09	60
2107	6.1	0	3.09	17	07	17	05	12	11	20	04	47
2208	3.5	1	2.73	30	15	16	07	19	09	22	09	59
2109	3.5	0	2.18	28	13	20	06	19	07	12	06	44
2110	6.5	4	1.11	29	11	19	05	20	12	23	12	67
2211	6.5	1	2.52	31	17	22	08	21	13	25	10	69
2212	7.7	1	1.42	27	15	21	10	23	11	25	13	72
2113	5.8	4	2.27	31	16	21	07	25	12	22	08	67
2214	3.5	0	1.95	26	14	12	04	09	11	17	07	44
2215	8.5	4	2.02	29	16	20	05	19	07	18	06	50
2216	6.5	0	2.52	23	08	16	06	20	06	16	02	44
2217	2.7	3	3.23	31	17	28	12	30	13	25	12	80
2118	5.5	0	1.64	29	13	19	10	19	11	23	08	61
2119	7.6	0	1.82	28	15	10	04	21	06	18	10	55
2220	2.7	2	2.41	29	12	16	05	20	12	21	07	60

TABLE XXXI (Cont'd.)

Ident. Number	Attitude Posttest	Films	Study Time	ACHIEVEMENT TESTS								
									Final Exam			
				I-1	I-2	II-1	II-2	A-1	A-2	B-1	B-2	Total
2221	7.9	2	3.64	29	14	20	07	21	12	26	11	70
2222	2.7	1	0.91	23	10	15	04	14	11	15	07	47
2223	6.1	1	2.94	20	12	14	05	15	07	13	08	43
2124	5.5	5	2.48	27	14	17	03	19	11	16	07	53
2125	4.7	2	2.09	31	15	25	06	23	15	27	12	77
2226	6.0	0	2.41	29	18	24	05	24	12	26	07	69
2227	7.1	1	1.68	28	16	17	05	18	09	18	08	53
2228	2.8	0	0.00	26	12	20	06	22	10	19	07	58
2129	8.6	4	2.32	32	16	26	06	25	12	24	10	71
2230	7.7	1	1.68	30	15	26	06	24	13	27	12	76
2231	7.7	1	1.20	29	09	17	06	23	06	25	09	63
2132	7.8	4	2.55	28	15	17	08	22	14	18	07	61
2133	7.8	3	3.20	28	12	22	10	25	14	22	09	70

TABLE XXXII

SUMMARY OF DATA FOR TREATMENT GROUP - DEPENDENT VARIABLES

				ACHIEVEMENT TESTS								
									Final Exam			
Ident. Number	Attitude Posttest	Films	Study Time	I-1	I-2	II-1	II-2	A-1	A-2	B-1	B-2	Total
1134	8.1	0	2.64	25	11	20	02	21	20	18	04	53
1135	2.8	0	3.00	22	05	11	04	17	07	25	08	57
1236	7.7	2	1.64	23	10	08	04	17	09	16	06	48
1137	3.6	0	4.07	27	12	20	07	19	11	25	10	65
1138	4.2	0	1.18	32	17	27	08	26	16	25	12	79
1239	7.7	1	2.50	31	16	28	08	27	14	25	13	79
1240	7.7	3	3.50	31	15	23	07	19	11	16	10	56
1241	2.9	0	1.94	30	15	25	10	26	17	26	13	82
1142	7.9	1	1.64	28	12	18	07	17	11	26	11	65
1243	7.7	4	3.18	30	08	20	04	18	06	23	09	56
1244	6.1	0	1.32	29	16	23	11	26	12	27	12	77
1245	7.1	2	3.27	29	13	23	08	31	13	26	09	79
1146	6.0	4	1.27	23	10	18	05	20	07	14	07	48
1147	7.7	4	3.23	27	13	23	07	22	13	23	07	65
1248	2.9	1	2.56	28	15	20	08	20	11	25	09	65
1249	8.3	2	0.82	31	18	18	08	17	11	22	09	59
1250	8.8	3	0.55	31	15	25	06	27	11	22	10	70
1251	5.8	0	2.46	31	17	28	13	27	15	29	15	86
1252	6.5	1	1.18	31	18	26	07	26	14	26	10	76

TABLE XXXII (Cont'd.)

				ACHIEVEMENT TESTS								
									Final Exam			
Ident. Number	Attitude Posttest	Films	Study Time	I-1	I-2	II-1	II-2	A-1	A-2	B-1	B-2	Total
1153	3.4	0	2.73	27	10	17	04	13	06	18	10	47
1154	7.7	0	1.77	23	14	18	05	17	13	18	08	56
1255	6.1	3	3.59	28	10	15	04	19	06	25	08	58
1256	5.8	3	1.32	28	13	19	07	24	11	25	09	69
1257	7.6	3	2.48	31	15	12	04	19	14	22	09	64
1158	8.6	4	5.10	28	10	21	06	18	09	25	06	58
1159	3.1	0	3.18	32	17	23	06	25	10	18	09	62
1260	2.7	0	1.50	22	13	13	03	16	08	26	08	58
1261	7.7	3	2.68	31	18	30	16	31	16	32	17	96
1262	8.1	3	2.68	22	12	11	06	19	14	18	04	55
1263	2.8	0	1.54	24	13	13	05	15	09	19	06	49

TABLE XXXIII

SUMMARY OF DATA FOR CONTROL GROUP - INDEPENDENT VARIABLES

Ident. Number	Attitude Pretest	SCAT Quant.	SCAT Verbal	Chemistry Pretest	First Semester Grade Point Ave.
2201	3.5	36	32	39	2.16
2202	3.2	29	26	41	1.78
2203	7.1	44	43	56	3.64
2204	2.8	45	42	53	2.63
2105	6.1	33	38	65	2.46
2106	8.5	26	32	48	2.44
2107	8.2	38	40	35	1.86
2208	7.7	23	35	49	3.13
2109	2.8	29	30	33	1.91
2110	7.9	33	36	46	2.88
2211	5.5	40	41	46	2.91
2212	8.1	39	32	51	2.88
2113	7.9	33	29	45	2.00
2214	3.0	40	41	52	2.03
2215	8.7	38	39	51	2.88
2216	6.8	29	38	40	1.38
2217	3.3	34	43	41	3.66
2118	6.8	40	34	39	2.63
2119	3.0	43	44	42	2.06
2220	6.3	33	35	47	3.00
2221	6.8	42	31	61	2.34
2222	8.4	39	42	49	1.81
2223	5.5	43	37	46	2.04
2124	6.0	35	37	42	2.43
2125	7.7	39	39	43	3.78
2226	6.1	33	41	54	3.18
2227	7.8	42	45	53	1.84
2228	2.5	41	41	52	2.64
2129	8.5	32	38	40	3.25
2230	8.4	46	36	50	2.17
2231	7.8	38	39	41	2.03
2132	5.8	40	38	47	2.91
2133	7.9	31	36	38	2.75

TABLE XXXIV

SUMMARY OF DATA FOR TREATMENT GROUP - INDEPENDENT VARIABLES

Ident. Number	Attitude Pretest	SCAT Quant.	SCAT Verbal	Chemistry Pretest	First Semester Grade Point Ave.
1134	7.9	29	37	32	2.06
1135	3.3	38	39	30	1.91
1236	7.8	24	27	41	1.81
1137	7.7	41	36	42	2.56
1138	6.7	30	30	57	3.86
1239	7.7	34	36	47	3.16
1240	7.8	35	35	43	2.47
1241	7.7	38	42	47	2.78
1142	7.8	38	36	50	2.28
1243	7.9	39	41	38	1.94
1244	5.8	39	42	52	3.25
1245	7.9	35	42	56	3.38
1146	6.0	34	41	51	2.19
1147	6.1	34	33	54	2.75
1248	7.9	39	35	44	2.13
1249	6.1	38	38	51	2.34
1250	8.7	40	44	58	2.89
1251	7.9	45	45	63	3.78
1252	8.6	36	45	44	3.50
1153	6.5	39	38	37	1.79
1154	8.0	31	31	42	2.38
1255	7.1	27	31	44	1.53
1256	6.1	44	44	63	2.72
1257	6.0	39	39	40	2.88
1158	8.6	28	30	39	2.28
1159	4.7	39	32	46	3.16
1260	4.7	35	38	45	2.03
1261	7.7	43	45	57	4.00
1262	8.5	38	42	42	1.69
1263	7.8	37	38	36	2.25

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