A STUDY OF VALUE ORIENTATIONS AS A CHARACTERISTIC OF SECONDARY SCHOOL STUDENTS AND TEACHERS OF CHEMISTRY AND AS A FACTOR IN LEARNING

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ABSTRACT

A STUDY OF VALUE ORIENTATIONS AS A CHARACTERISTIC OF SECONDARY SCHOOL STUDENTS AND TEACHERS OF CHEMISTRY AND AS A FACTOR IN LEARNING

By

Peter Henry Huston

Many observers have recognized that recent high school science curricula, which have placed emphasis on the abstract, theoretical aspects of science, have been ineffective in stimulating secondary school science students. They have suggested that modern students would be more receptive to applications of science in their contemporary technological culture and to concerns such as pollution which affect the human status.

This study measured and compared the value orientations of students and teachers of secondary school chemistry to the theoretical, humanistic and technological aspects of chemistry. To do this a Chemistry Preference Evaluation Instrument of 24 sets of alternative statements was developed, containing in each set alternatives stressing the theoretical, humanistic and technological aspects of particular chemical phenomena or facts. The content validity of the instrument was established by the categorization of a panel of five experts. The construct validity of the instrument was supported by higher scores of the Theology students towards the humanistic and Engineering Science students on the theoretical with both differences significant at the .001 confidence level.

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The instrument was administered to 120 grade 12 chemistry students in secondary school A in London, Ontario and to 39 chemistry teachers employed by the London Board of Education. The reliability coefficients, all significant at the .001 confidence level were: humanistic .85 and .78; theoretical .90 and .85; technological .77 and .72 for students and teachers respectively.

The relationships of levels of value orientation to student and teacher characteristics were examined. Male students scored significantly higher on the technological and female students on the humanistic. A higher humanistic and technological orientation was associated with fewer courses in university chemistry preparation and a greater number of years teaching experience whereas a higher theoretical orientation was associated with a greater number of courses in university chemistry preparation and fewer years teaching experience. The teaching of biology at least quarter time was associated with higher technological and lower theoretical orientations.

The differences in the means of the scores obtained on the Chemistry Preference Evaluation Instrument between students and teachers were all significant at the .001 confidence level.

	Teachers	Students
Humanistic Value Orientation	21.0	30.1
Theoretical Value Orientation	30.6	17.3
Technological Value Orientation	20.2	26.1

Evidence on advance organizers and the retention of controversial material supported the general concept that learning was related to the extent to which the learner perceived the material to be learned as meaningful.

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Peter Henry Huston

A fixed effects factorial model was employed with the subjects blocked into three levels on the humanistic value orientation scores and two levels on their chemistry grades. Three treatments, consisting of humanistic, technological and placebo introductions to each of five programmed units in organic chemistry, were administered during regularly scheduled class periods. The dependent variables were a humanistic subscore on 23 humanistic items and a total score on all 59 test items. The reliability coefficients, both significant at the .001 confidence level, were .75 and .88 respectively. The data was analysed by means of three way analysis of variance and significant interactions were gaphed for analysis.

There was no significant difference in learning between experimental treatments or that could be attributable to levels of humanistic value orientation. The interaction of treatments with chemistry grades was significant at the .05 confidence level for humanistic subscores only. The interactions of levels of chemistry grades with levels of humanistic value orientation was significant at the .05 confidence level for both humanistic subscores and total scores.

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Peter Henry Huston

A THESIS

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DEDICATION

Dedicated to the memory of the late L. Glen Mitchell who made Science come alive for so many. His intellectual curiosity, personal concern for his students and emphasis on excellence will always be an inspiration.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the many students and teachers whose co-operation made this research possible. My thanks also, to members of the panel, to Dr. R.G. Stennett and his colleagues, and to Dr. J.R. Brandou and Dr. J.B. Kinsinger of the guidance committee, for their generous assistance and advice.

Most particularly, I would sincerely like to thank Professor Wm. J. Walsh for his gracious understanding, kindly encouragement and sagacious advice in the development of this study.

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CHAPTER I

INTRODUCTION

I. THE PURPOSE OF THE STUDY

The purpose of this study was to measure and compare the orientations of secondary school chemistry students and teachers towards three aspects of chemistry: the humanistic, the theoretical and the technological. The relationship of levels of orientation of selected student and teacher characteristics was examined to discover patterns of orientation that may have occurred. The study attempted to determine whether the level of orientation of students towards a particular value, such as the humanistic, affected the measured learning of humanistic and non-humanistic material given by programmed instruction. This experiment also attempted to determine whether any change in learning could be measured and attributed to written program introductions oriented towards a particular aspect of chemistry, in particular the humanistic.

II. THE STATEMENT OF THE PROBLEM

The focus of the problem under study was multi-dimensional:

A. To measure the value orientations of secondary school chemistry students and to examine the correlation of theoretical, humanistic and technological values with student characteristics of sex, measured intelligence, general academic average and performance as measured by chemistry grades.

B. To measure the value orientations of secondary school chemistry teachers and to examine the relationship of these measured values with teacher characteristics of number of years teaching experience, levels of university science preparation, and biology as a significant part of the assigned teaching load.

C. To compare the value orientations of secondary school chemistry students with those of secondary school chemistry teachers.

D. To study possible variations in measured learning of materials classified as both humanistic and non-humanistic with levels of humanistic value orientation of students.

E. To study the effect on measured learning caused by varying the value orientation of the introduction to a module.

III. DEFINITION OF TERMS

Theoretical value - the strength of this value is indicated by the extent to which the individual prefers or considers most worthwhile those activities which order and systematize knowledge. (i.e. the principles, models, systems and hypotheses of science)

Humanistic value - the strength of this value is indicated by the extent to which the individual prefers or considers most worthwhile those activities which involve a concern for human nature and improvement of the human condition.

Technological value - the strength of this value is indicated by the extent to which the individual prefers or considers most worthwhile those activities which involve the production and utilization of material goods.

Module - a short learning experience with specified objectives.

Placebo - a treatment similar in appearance to the experimental treatments which is given to the control group to preclude the appearance of inequality acting as a confounding variable.

Advance organizer - concepts or principles introduced before the main body of instructional material so as to explain and organize the material and facilitate learning.

IV. DELIMITATIONS OF THE STUDY

A complete profile of values was not measured, but only those selected as important: theoretical, humanistic and technological.

Long term changes were not measured since these would be inconsistent with the evaluation of a modular experience.

Value orientations of subjects and instruction were limited to those directly applicable to the study.

The effectiveness of changing the modular experience was measured by a curriculum embedded test so as to be consistent with modular instruction.

V. THE IMPORTANCE OF THE STUDY

The intrinsic preference of students for various aspects of the field of chemistry would seem to be of particular importance to secondary chemistry teachers in planning instruction. Recent attempts to improve chemistry curricula have been increasingly theoretical[1] and lacked appeal for many students.[2] Ronald S. Ratney described the current situation in this way:

> Tell a class that chemists are mounting an assault on the unknown and it will yawn; show how the atomic theory is as mighty an intellectual achievement as Shakeaspeare's plays and it will tune you out. But show how chemistry helps fight disease, hunger, poverty and pollution, and then, maybe students will come and listen.[3]

A similar situation has been recognized in secondary school physics with the resulting intent of humanistic emphasis in Harvard Project Physics.[4]

Experimental evidence which would suggest that students indeed do view the humanistic and technological aspects of chemistry as being equally important as the traditional theoretical aspects would provide strong support for efforts to increase instructional emphasis on these aspects of chemistry. This emphasis might be provided in the construction of the curriculum itself or by enrichment activities provided by the classroom teacher. Comparisons of the relative value orientations of students and chemistry teachers would provide evidence for the question of whether present instruction in chemistry is oriented towards the areas that students

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[1]Eric Hutchinson, "Fashion in Science and in the Teaching of Science," The Journal of Chemical Education, 45 (September, 1968), 606.

[2]Derek A. Davenport, "Elevate Them Guns a Little Lower," The Journal of Chemical Education, 45 (June, 1968), 419.

[3]Ronald S. Ratney, "Two Views," The Journal of Chemical Education, 45 (April, 1968), 246.

[4]G. Halton, F. G. Watson and F. J. Rutherford, "A Message from the Directors," Newsletter 7, Harvard Project Physics, (Spring, 1968), 4.

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or teachers view as being most important. As Butts has said, "Students must feel that they are studying something of value and not merely executing intellectual minuets."[5]

The theoretical, humanistic and technological dimensions are not mutually exclusive but occur simultaneously in varied proportions. Both theory and technology, for example, require people for their very existence, but their main thrust is not directed toward the persons involved. Could not some of the power of objective theory or modern industrial production in fact be related rather to their very impersonality?

The significance of a particular scientific event or phenomenon may be conceptualized as being located in space relative to the three values, or dimensions, humanistic, theoretical and technological as illustrated in Figure 1.1. Therefore the

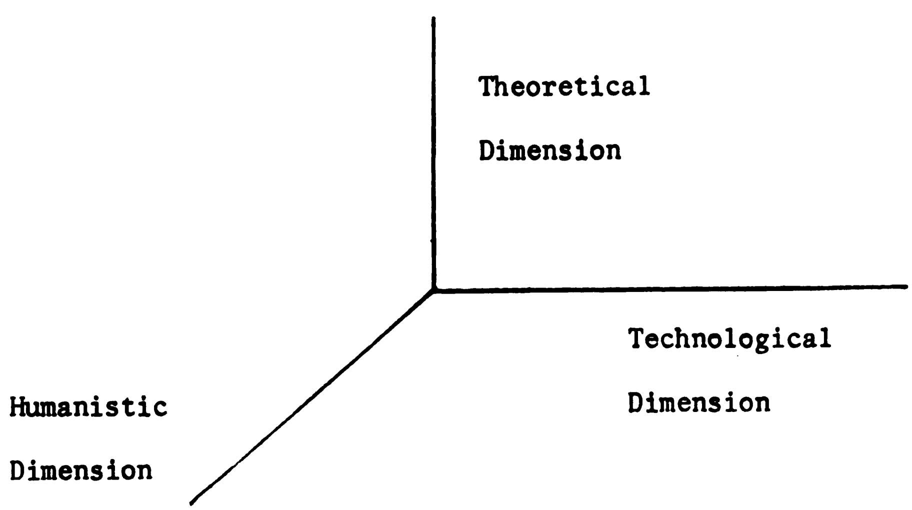

FIGURE 1.1

AXES OF SCIENTIFIC SIGNIFICANCE

[5]David P. Butts, "Opening the World to the Student," Designs for Progress in Science Education, (Washington: National Science Teachers' Association, 1969), 32.

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relevance of perceived location of significance of a scientific event depends upon the perspective, or value orientation, of the individual.

The optimal learning situation occurs when instructional variables can be matched with individual learning characteristics.[6] This is an aim in personalizing instruction in such innovative programs as BSTEP[7] under development at Michigan State University. Modules are employed to provide the necessary flexibility in instruction, but the relationship between learner characteristics and the effectiveness of various modular variations requires investigation.[8] The use of various types of introductions to a module to motivate and perhaps serve as an advance organizer[9] could provide an economical method of introducing variation. This study was designed to explore the influence of a modular introduction upon measured learning. An integral part of the study was to examine the effect on learning which occurred when both the module and the introduction were oriented toward a particular learner perspective

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[6]Lee J. Cronbach, "The Two Disciplines of Scientific Psychology," The American Psychologist, 2(November, 1957), 681.

[7]Behavioral Science Teacher Education Program, Project Number 89025, United States Department of Health, Education, and Welfare, 3 Volumes, (1968).

[8]Feasibility Study Behavioral Science Teacher Education Program, Project Number 320424, United States Department of Health Education, and Welfare, (1969), pp 360-362.

[9]David P. Ausubel, Educational Psychology: A Cognitive View, (New York: Holt, Rinehart and Winston, Incorporated, 1968), pp 136-138.

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as well as the use of an introduction which emphasized a different dimension than the module itself. The possible interaction between characteristics of the learner and the dimension of modular introduction, in itself would be valuable in module design and construction.

The study recognized that learning may be a function of the value orientation of the instruction along the varying dimensions of the theoretical, humanistic or technological and that this direction could be derived either from the orientation of the instructor or the orientation inherent in the curricular material itself. Therefore the amount of measured learning may depend on whether the instruction on this particular phenomenon emphasized humanistic applications, such as a medicinal use, or the principles and models involved in an explanation of the phenomenon.

VI. THE ORGANIZATION OF THE STUDY

In chapter two the literature of values in modern science is reviewed as well as an approach to measuring values. Some of the experimental evidence relating learning to attitudes is identified and the use of advance organizers briefly considered.

An instrument to measure value orientations in chemistry is described in chapter three and its use to measure and compare the value orientations of teachers and students outlined. An experimental procedure to study the effect of value orientations on measured learning is described as well.

In chapter four the experimental data are summarized and analysed according to the procedures outlined in chapter three.

CHAPTER II

REVIEW OF THE LITERATURE

I. SCIENCE AND VALUES

Rokeach has defined a value as "an enduring belief that a specific mode of conduct or end-state of existence is personally and socially preferable to alternative modes of conduct or end-states of existence."[10] Wilson has indicated that contemporary education does not reflect and is often at variance with the values that present day students hold important.[11] She called for science to become more humanistic and consonant with the great idealism and deep concern that modern students hold for human needs. Much earlier, Bacon had expressed the aim of science to be the improvement of man's lot, but more recently science has been stressed as an intellectual adventure whose justification was the exercise of man's mind upon the world of physical phenomena.[12] According to a study

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[10] Milton Rokeach, "A Theory of Organization and Change Within Value-Attitude Systems", Journal of Social Issues, 24 (1968), 16.

[11] Evelyn H. Wilson, "Why Not Science?", The Journal of Chemical Education, 46 (August, 1969), 484.

[12] Moody E. Prior, Science and the Humanities (Evanston: Northwestern University Press, 1962), 60.

by Kimball[13], 58 percent of the teachers questioned disagreed with the statement, "The primary objective of the working scientist is to improve human welfare", and 72 percent disagreed with emphasis on the practical being an important part of scientific enterprise.

Recent high school science curricula have been "more logical, more rigorous and more abstract"[14] than their predecessors. Curriculum development was funded by the National Science Foundation which Gatewood[15] has suggested was staffed largely by research scientists who supported projects dominated by other research scientists. This caused a process of natural selection whereby technology and other applied science were omitted in order to produce courses oriented towards higher study in pure theoretical sciences. C. P. Snow[16] has illuminated the attitudes of the research scientists whose assumed superiority to the "second-rate minds" in applied science varied directly with the extent of removal from any practical application. A similar trend was observed by Hopkins who stated, "Currently the developing curricula in science show a rapid movement away from the technical to the theoretical bases of the science."[17]

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[13]Merritt E. Kimball, "Understanding the Nature of Science: A Comparison of Scientists and Science Teachers," Journal of Research in Science Teaching, 5 (1967-1968), pp. 110-120.

[14]Derek A. Davenport, op. cit.

[15]Claude Gatewood, "The Science Curriculum Viewed Nationally," The Science Teacher, 35 (November, 1968), pp. 18-21.

[16]C. P. Snow, The Two Cultures, (New York: Cambridge University Press, 1959), 34.

[17]Stephen Hopkins, "Science-Technology: An Introduction to Technology for High School Students," The Science Teacher, 35 (May, 1968), 39.

Certainly the theoretical aspects of science should not be ignored, and writers such as Poincaré[18] have made a strong case for the importance of the structure of science. There were two dangers, however, in too great an emphasis on the theoretical aspects of science. First there was the danger of loss of contact with reality. The emphasis on model building with several degrees of abstraction concerning a host of individually invisible particles might lose touch with reality for the student. Hutchinson[19] has drawn a parallel with medieval scholasticism which applied great logic and imaginative argument to sophisticated models but died because sophisticated argument was given priority over concrete reality until the arguments and models were almost completely divorced from reality. Secondly, the curricula tended to become elite science curricula which were "essentially irrelevant to the needs of the major portion of the students."[20]

Students should not find their contact with science an unhappy experience[21] but find it stimulating, vital and relevant. Science may have appeared to lack relevance for many students[22] because it was unrelated to their vocational goals, to their view of

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[18] Henry Poincaré, _The Value of Science_, (New York: Dover Publications Incorporated, 1958).

[19] Eric Hutchinson, _op. cit._

[20] Claude Gatewood, _op. cit._, 19.

[21] Elizabeth A. Wood, "The Physical Science for Nonscience Students Project," _The Journal of Chemical Education_, 46 (February, 1969), 69.

[22] M. Abraham and P. Westmeyer, "Chemistry is in Trouble," _Chem 13 News_, (November, 1970), 8.

the solution to social and other problems in the real world and because science appeared mechanistic and dehumanized in contrast to their studies in the humanities.[23]

Maslow has rejected the concept of science being value free and having nothing to say about the "goals, the purposes, the rewards or the justification of life."[24] Bronowski[25] claimed that the truly important thing about science was the values of tolerance, independence and dissent demonstrated by the community of scientists. This respect for others, while questioning their views, has led to rejection of early theories, while still honoring the men who first stated them. The critical aspect of the "scientific method," as Bronowski saw it, was the values which made it work; values of justice, honor, and respect between man and man which were necessary for science to continue to explore truth. The separation between science and humanities could be reduced by stressing the humanistic aspects of science in order not only to reduce the separation between scientists and humanists, but also to reduce this tension within individuals.[26] Thus a consideration of the value components of science might help students to find "a sense of the unity of science

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[23]Wm. F. Henry, "The Issues in Campus Unrest," Phi Kappa Phi Journal, (Fall, 1969), pp. 21-27.

[24]Abraham H. Maslow, The Psychology of Science, (New York: Harper and Row Publishers, 1966), 120.

[25]J. Bronowski, Science and Human Values, (New York: Harper and Row Publishers, 1968).

[26]W. T. Jones, The Sciences and the Humanities, (Berkeley: The University of California Press, 1965), 10.

with life as a whole,"[27] especially if the role of science in solving some of mankind's problems such as hunger and disease was emphasized.[28,29,30] In an address to the AAAS meeting of Educational Policies Commission, I. I. Rabi stressed the importance of orientation towards the humanistic values in science in these words:

> So what I propose as a suggestion for you is that science be taught at whatever level, from the lowest to the highest, in the humanistic way. By which I mean, it should be taught with a certain historical understanding, with a certain philosophical understanding, with a social understanding and a human understanding in the sense of the biography, the nature of the people who made this construction, the triumphs, the trials, the tribulations.[31]

Another aspect of chemistry which it has been suggested would promote more student interest was the application of the prinicples learned in the classroom to the technology of modern industry.[32,33] If directed to local industries or consumer

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[27]Harry S. Broudy, "Science and Human Values," The Science Teacher, 36 (March, 1969), 27.

[28]James Bryant Conant, Modern Science and Modern Man, New York: Columbia University Press, 1952), 86.

[29]I. I. Rabi, Science: The Center of Culture, (Cleveland: The World Publishing Company, 1970), 58.

[30]W. F. Libby, "Values in Chemistry," The Journal of Chemical Education, 46 (April, 1969), pp. 190-192.

[31]I. I. Rabi, "From the address of I. I. Rabi at AAAS meeting of Educational Policies Commission, 27 December, 1966, Washington, D.C.", The Physics Teacher, 5 (May, 1967), 197.

[32]Louise Albertson, "Comparative Analysis of CHEM Study and its Revisions," Canadian Chemical Education, (April, 1971), 11.

[33]Henry Gehrke, Jr., "Letters to the Editor," The Journal of Chemical Education, 45 (June, 1968), pp. 441-442.

products, chemistry would thus be prevented from becoming disembodied, an entity apart from the real world away from school. Thus opportunity of consolidating knowledge and implementing fresh approaches would constantly be presented. Weinberg[34] has gone so far as to suggest that the application of science may become the dominant mode in teaching science.

II. VALUES AND ATTITUDES

Most discussions and examinations of present day science instruction have been reducible to consideration of three values: theoretical, humanistic and technological. Although these three values were related to three of Spranger's[35] six basic types of men, (theoretical, economic, social, aesthetic, political and religious), they were selected in the study on the basis of the literature of modern science instruction rather than acceptance of Spranger's model. Although a value was not sharply distinguished from an attitude, an attitude was generally focused on a specific object and as such was not as fundamental as a value.[36] The attitude towards an object was affected not only by one or more values, which may have been supportive or competing, but also by the individual's perception of the object.

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[34] Alvin M. Weinberg, "The Two Faces of Science," The Journal of Chemical Education, 45 (February, 1968), pp. 74-77.

[35] Lee J. Cronbach, Essentials of Psychological Testing, (second edition; New York: Harper and Row Publishers, 1960), 323.

[36] A. N. Oppenheim, Questionnaire Design and Attitude Measurement, (New York: Basic Books Incorporated, 1966), 109.

III. THE MEASUREMENT OF VALUES

Thus value orientations measured with respect to a variety of science objects would be more valid for use in modifying science instruction than values measured with reference to non-science objects.

Since an individual holds many values simultaneously, the mere presence or absence of values was of less consequence than the relative strength of the values. Thus a forced choice to rank order three alternatives, each corresponding to a theoretical, humanistic or technological value, would indicate the relative strength of these values.[37] Although this forced choice method produced an ipsative relationship, (i.e. one decreases as others increase) among the value scores, it appeared more intimately related to the definition of value, "...is personally...preferable to alternative modes..." than a system which would attempt to measure the intensity of particular values on separate scales and then assume equal intervals on thse separate scales for the purpose of comparison.[38,39] The study of values by Allport, Vernon and Lindzey[40] was based on Spranger's six basic types of men and used

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[37]Abraham H. Maslow, op. cit., 124.

[38]Joseph E. Shorr, "The Development of a Test to Measure the Intensity of Values," Journal of Educational Psychology, 44 (May, 1953), pp. 266-274.

[39]A. L. Edwards and K. C. Kenny, "A Comparison of the Thurstone and Likert Techniques of Attitude Scale Construction," Journal of Applied Psychology, 30 (1946), pp. 72-83.

[40]Gordon W. Allport, Philip E. Vernon and Gardner Lindzey, Study of Values: A Scale for Measuring the Dominant Interests in Personality (third edition; Boston: Houghton Mifflin Company, 1965).

a forced choice response. Although the described values of theoretical, economic and social were reasonably parallel to the selected values of theoretical, technological and humanistic respectively, the social value score had low reliability and was described by Meehl[41] as ambiguous. The revised forms of 1959 and 1965 did not appear to have overcome this deficiency sufficiently for use in the study where the humanistic value score was of importance.

IV. VALUES, ATTITUDES AND LEARNING

The old adage, "We teach what teachers think is meaningful, but students learn what they think is meaningful" suggested that to increase learning more material which students find meaningful should be incorporated in the curriculum. Levine and Murphy[42] showed that an individual learned and remembered best controversial material which was consistent with his relevant attitude, however these findings were not confirmed in a replication performed by Waly and Cook.[43] The literature has indicated that students would find increased emphasis on the humanistic and

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[41] Paul E. Meehl, "A Review of Study of Values: A Scale for Measuring the Dominant Interests in Personality," The Third Mental Measurements Yearbook, (New Jersey: The Gryphon Press, 1931), 99.

[42] J. M. Levine and G. Murphy, "The Learning and Forgetting of Controversial Material," Journal of Abnormal and Social Psychology, 38 (1943), pp. 507-517.

[43] P. Waly and S. W. Cook, "Attitude as a Determinant of Learning and Memory: A Failure to Confirm", Journal of Personality and Social Psychology, 4 (1966), pp. 280-288.

technological aspects of science both interesting and stimulating, however the relative importance of these aspects compared to the theoretical aspects was not described.

Although teachers have traditionally been educated to introduce each lesson in such a manner as to enhance its meaning, Shuck has shown that training teachers to induce a pre-instructional mental set to make the material more meaningful, produced a significant increase in student learning.[44] Ausubel has demonstrated the use of an advance organizer to aid retention of meaningful material, but it did not always induce a gain in learning.[45] A purely expository organizer was found to facilitate learning only for those with lower verbal ability who apparently had less ability of their own to organize new material in relation to existing cognitive structure.[46] Pella and Triezenburg discovered that verbal references, working models and sketches work equally well as advance organizers when the desired level of understanding was knowledge or application. They failed to show an actual gain in learning due to the presence of the organizer as they omitted a control group.[47]

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[44]Robert F. Shuck, "The Effects of Set Induction upon the Achievement of Ninth-Grade Pupils and their Perception of Teacher Effectiveness," The Journal of Educational Research, 62 (February, 1969), pp. 279-285.

[45]David P. Ausubel, "The Use of Advance Organizers in the Learning and Retention of Meaningful Verbal Material," Journal of Educational Psychology, 51 (1960), pp. 267-272.

[46]D. P. Ausubel and D. Fitzgerald, "Organizer, General Background and Antecedent Learning Variables in Sequential Verbal Learning," Journal of Educational Psychology, 53 (1962), pp. 243-249.

[47]M. O. Pella and H. J. Triezenburg, "Three Levels of Abstraction of the Concept of Equilibrium and its use as an Advance Organizer," Journal of Research in Science Teaching, 6 (1969), pp. 11-21.

Winter[48] demonstrated that student grades were correlated to the degree of similarity in values between a student and his teacher, although this may have been due to bias in measurement rather than a significant difference in actual learning. It may be difficult for a teacher to effectively implement a curriculum which does not coincide with his value orientations.[49] The whole teaching-learning complex may have interactions between many factors such as value orientations, learning styles, instructional methods, teacher behaviors and the nature of the content to be learned. The nature of the content of the learning experience was demonstrated to be a critical factor in the relationship between learner characteristics and the method of instruction.[50] The optimal leaning situation for each individual could be closer to realization if interactions between content and learner orientations could be measured.

The attitudes toward science have an importance beyond affecting the learning of new material, since they also affect the eventual application of the acquired knowledge.[51]

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[48] W. D. Winter, "Student Values and Grades in General Psychology," Journal of Educational Research, 55 (April, 1962),332.

[49] Robert Emans, "Teacher Attitudes as a Function of Values," Journal of Educational Research, 62 (July, 1969), pp. 459-463.

[50] James W. Shearer and G. K. Tallmadge, "Relationships Among Learning Styles, Instructional Methods and the Nature of Learning Experiences," Journal of Educational Psychology, 60 (April, 1969), pp. 222-230.

[51] G. A. Ramsay and R. W. Howe, "An Analysis of Research on Instructional Procedures in Secondary School Science. Part I - Outcomes of Instruction," The Science Teacher, 36 (March, 1969), 66.

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V. SUMMARY

Recent high school science curricula have emphasized theoretical aspects of science at the expense of humanistic and technological aspects. This emphasis on the theoretical appeared to be at variance with student values and contributed to seeming lack of relevance and resultant decreasing student interest. Stress on humanistic aspects of science was not only in accordance with the spirit of scientific inquiry but while helping to bridge the gulf between the humanistic and scientific communities would integrate these outlooks within individuals to help them perceive the unity of science with all of life. Similarly more stress on the technological aspects of science would promote student interest and prevent divorce of science from the real world. However the relative importance which either students or teachers perceived in the various value components of science had not been reported.

An individual holds many values simultaneously, but as Maslow has indicated, a study of preferences may be used to study values and thus their relative strengths.

Evidence on advance organizers and the retention of controversial material supported the general concept that learning was related to the extent to which the learner found the material meaningful. The perception of the inherent meaning of material was related to the individual's frames of reference or value orientations.

CHAPTER III

PROCEDURE AND IMPLEMENTATION OF THE STUDY

I. THE STUDY OF VALUE ORIENTATIONS

Development of the Instrument

The Generation of Items In order to gain an indication of an individual's preference for the humanistic, theoretical and technological aspects of chemistry, the individual was presented with sets of three alternative statements, one dominated by each value, and asked to rank order them according to his personal preference or idea of their importance. The individual was instructed[52] to consider the three alternatives as equally correct and not to attempt to assess their relative correctness. Following is a sample item from the Chemistry Preference Evaluation Instrument.[53]

> The Haber Process makes ammonia from hydrogen and nitrogen.
> a) The use of ammonia as a fertilizer raises food production closer to population requirements.
> b) Ammonia is a basic compound for the fertilizer and explosives industry.
> c) To maximize production of ammonia by this process, pressure and concentration must be regulated according to the principles of chemical equilibrium.

This item was designed to present option a) as appealing to the humanistic value of a concern for the improvement of the human condition, while option b) stressed the technological value of producing material goods whereas the selection of option c) was

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[52]Appendix A, 68.

[53]Appendix A, 69.

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consistent with a concern for the theoretical aspect of chemistry: in this instance the principles of chemical equilibrium.

After the individual had indicated his first and second choices on a number of sets of alternative statements, the selections were scored with two points for a first choice and one point for a second choice. Points were summed for all sets of alternatives ultimately providing three scores for each individual, representing a measure of his orientation towards the humanistic, theoretical and technological values in chemistry.

As the test items were developed they were administered to classes of students in secondary schools B, C and D in London judged similar to the experimental student population of school A. The results of the tests were key-punched and scored by computer. Students were then rank ordered on one set of scores, such as the humanistic, and the degree of discrimination analysed by comparing the total score of the top and the bottom twenty-five percent of the sample on the same item. The items themselves were then revised after this experimental testing and many were discarded to successfully develop alternative statements which were discriminating and would be selected with equal frequency. This revision procedure was continued until twenty-five sets of alternative statements were developed.

<u>Content Validity</u> The content validity of the categorization of the sets of alternatives as being humanistic, theoretical or technological was established by submitting the statements to a panel for categorization. In order that the panel encompass a

range of experts, it was composed of a professor of chemistry, a professor of curriculum and chemistry methods, a science consultant, a high school science teacher and a female graduate student in education.[54] The panel members were asked to categorize the alternative statements of each item as humanistic, theoretical, technological or "none of these" according to the definitions provided them.[55] Only items for which at least eighty percent of the panel had agreed on the classification of the three alternative statements as humanistic, theoretical and technological were retained.

Reliability The statistical reliability for each type of score, such as the humanistic, was determined by using a Kuder-Richardson reliability coefficient as a measure of internal consistency. Since one alternative of a particular set of items could receive either a first or second ranking score, conventional formulae for reliability coefficients based on correct and incorrect responses were not appropriate. The general Kuder-Richardson Formula,[56] permits a score to be tabulated for each item, thus it was appropriate in calculating the reliability coefficients.

$$r = \frac{k}{k-1}\left[\frac{1 - n\Sigma Q^2 - \Sigma T^2}{n\Sigma X^2 - (\Sigma X)^2}\right]$$

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[54]Panel, Appendix B, 77.

[55]Appendix B, 78.

[56]Robert L. Ebel, Measuring Educational Achievement, (Englewoods Cliffs, New Jersey: Prentice-Hall Incorporated, 1965), 328.

in which:

k is the number of items

n is the number of students

$\sum Q^2$ is the sum of the squares of the k times n individual question scores

$\sum T^2$ is the sum of the squares of the k question total scores

$\sum X^2$ is the sum of the squares of the n student total scores

$\sum X$ is the sum of the n student total scores

Since administration of the instrument produced three scores, a reliability coefficient was required for each score. The reliability coefficients obtained on the experimental populations of 120 students and 39 teachers were:

	students	teachers
humanistic	0.86	0.78
theoretical	0.90	0.85
technological	0.77	0.72

All coefficients were statistically significant at the .001 confidence level.

<u>Construct Validity</u> The final set of twenty-four items was distributed to twenty-five third year Engineering Science students and twenty-four Theology students in their third or fourth year of university. Nineteen volunteers from each group returned the response sheets soon enough to be included in the study. The mean scores of each group were as shown in table 3.1.

TABLE 3.1

COMPARISON OF SCORES OF THEOLOGY AND ENGINEERING SCIENCE STUDENTS

	Theology Students	Engineering Science Students	
Mean Humanistic Score	31.5	20.4	*
Mean Theoretical Score	15.7	25.7	*
Mean Technological Score	24.7	25.5	

As Raths[57] has pointed out, it is difficult to establish construct validity in the values area, however the Theology students were more highly oriented towards the humanistic as would be expected from their vocational commitment and training. Similarly the higher theoretical orientation of the Engineering Science students was consistent with their training and also the validity of the instrument.

The Sample

Students The population was comprised of 120 students enrolled in grade twelve chemistry at secondary school A, enrollment 1150, in London, Ontario. The school was in a suburban setting, drawing from middle socio-economic levels. Students in the population, equally divided by sex, had completed two years of general science and one year of physics in secondary school. They were enrolled in university preparatory courses and comprised the upper academic two-thirds of the grade twelve enrollment. The mean IQ of the population was 114.

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[57] James Raths, "Values and Valuing," Educational Leadership, (May, 1964), 544.

* The difference is significant at the 0.001 level.

All students in the population were in the sample in order to employ a fixed effects model.

Teachers The study population was the thirty-nine teachers employed by the London Board of Education teaching chemistry in a secondary school for the school year 1970-1971.

Measures

Students The student characteristics of IQ, academic average, chemistry grade and sex were obtained from the Ontario School Record files in the school. The test instrument seeking the humanistic, theoretical and technological orientations was administered during a chemistry class. The reliability coefficients obtained on the student population with this instrument indicated that the scores were sufficiently reliable for the purposes of the study.

Teachers An explanatory letter,[58] a questionnaire[59] and the Chemistry Preference Evaluation Instrument were distributed to all chemistry teachers in the secondary schools in London. Teacher characteristics were obtained from the responses on the questionnaires. The reliability coefficients obtained on the teacher population with the test instrument were all significant at the .001 level indicating that the value orientation scores possessed adequate reliability for the study.

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[58]Appendix B, 87.

[59]Appendix B, 88.

Hypotheses Tested

The main concepts in the study of value orientations were reflected in the null hypotheses which were then rejected or not as the data indicated. In the purposes of the study, it was assumed there would be:

A. No correlation between the student characteristics of measured intelligence, general academic average and chemistry grade and the humanistic, theoretical and technological value orientations.

B. No difference in the mean value orientations of male and female students.

C. No difference in the mean value orientations of teachers between those with a greater number of years teaching experience and those with less teaching experience.

D. No difference in the mean value orientations of teachers between those with a greater number of university chemistry background courses and those with fewer courses.

E. No difference in the mean value orientations of teachers between those who teach biology at least quarter time and those who do not.

F. No difference in the mean value orientations of students and teachers.

Analysis

Student Data Correlation coefficients between scores on the humanistic, theoretical and technological value orientations and the student characteristics of measured intelligence, academic average and chemistry grade were calculated using an Olivetta

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Underwood Programma 101 Computer. A t-test was used to test for significant differences between the male and female students' mean scores on the humanistic, theoretical and technological.

Teacher Data To investigate the possible relationship of both the level of university chemistry preparation and the number of years teaching experience with the value orientations scores, the sample was divided into two levels for each characteristic and the means compared gaphically. The largest differences were tested for significance using a t-test. The levels of teaching experience used included those teachers with less than five years teaching experience and others with five or more years teaching experience. The levels of university chemistry preparation were established on the basis of completing more or less than ten chemistry courses.

The means on the value orientation scores of teachers with five or less chemistry courses who taught biology were compared with the means of teachers with five or less chemistry courses who were not teaching biology. The significance of each difference was determined with a t-test.

The differences in the mean value orientation scores for students and teachers were compared using a t-test.

II. LEARNING AS A FUNCTION OF VALUE ORIENTATION

Sample

All the grade twelve chemistry students of school A were divided into three levels on the humanistic score as measured by the Chemistry Preference Evaluation Instrument. The population was further divided into two levels of performance in chemistry as determined by the two teacher assigned grades for the year. Thus subjects were assigned to six cells with three levels of humanistic orientation and two levels of chemistry performance. Students with identical scores on either of the two variables were assigned in such a way as to make the cell sizes as nearly equal as possible.

The subjects were then randomly assigned to three treatment groups, providing 18 cells in all. Since equal cell sizes were necessary for the statistical analysis, subjects had to be eliminated from some cells. The first criterion for this was maintaining independence between subjects. Subjects who had been absent on the day a particular unit of the treatment was administered received that particular treatment upon returning to school. Since this increased the possibility of collaboration and resulting loss of independence, these subjects were eliminated from the cells wherever possible. The remainder of the eliminations was random.

Measures

A series of five units of programmed instruction in organic chemistry was written with care being taken to include information which would be classified as humanistic. For example, an item was designed around the operation of the commonly used breathalyzer to detect impaired drivers. A ten minute test of about 12 items was given at the completion of each program. The tests were completion type and included items which were both humanistic and non-humanistic.[60] At least eighty percent of the

[60] Unit tests, Appendix C, 132.

panel[61] was in agreement with the categorization of each item as humanistic or non-humanistic.

Both the programmed instruction and the tests were revised on the basis of trials with students judged similar to the experimental population of school A. A score on 23 humanistic items over the five tests had a reliability coefficient of 0.75 and the total score on 59 items over all tests had a reliability coefficient of 0.88. These reliability coefficients were calculated using the Kuder-Richardson Formula 20 and were both significant at the .001 confidence level.

Design

Treatments The experimental treatments consisted of the introductory sheets for each programmed unit.[62] Treatment I introduction gave organizational information, such as "look for the patterns of chemical names and patterns of structure which...", and an appeal to the humanistic aspect of chemistry for motivation. Similarly, Treatment II introduction contained an equal amount of organizational information but the technological aspect of chemistry was used for motivation. Treatment III was a placebo introduction which gave about the same amount of relevant information as the other two, but did not attempt to motivate learning. The placebo treatment was necessary so the scores of control subjects would not vary due to visibly unequal treatment. At least eighty percent of the panel agreed with the classification of the introduction.

The treatments extended over five units and five class periods to provide sufficient contact with this method of instruction

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[61] Panel, Appendix B, 77.

[62] Experimental Treatments, Appendix C, 89.

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and to ensure that response to a novel situation was not an unusual factor. Programmed instruction was featured to minimize the teacher as a confounding variable.

Statistical Model The statistical model of the study was a fixed effects factorial model. All independent variables were fixed and crossed. The use of fixed variables permitted generalization of the finding to all populations judged similar. Blocking on the factors of levels of chemistry grade and levels of humanistic orientation scores increased the sensitivity of the statistical tests. This model allowed significance tests for all main effects and all interactions.

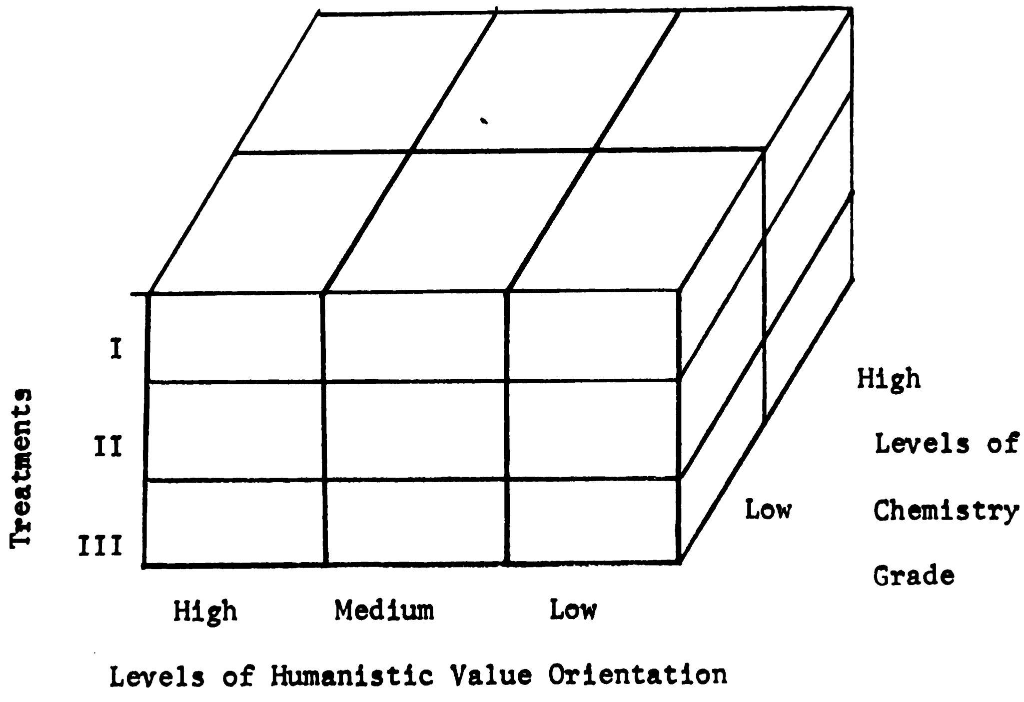

FIGURE 3.1

STATISTICAL MODEL

The dependent variable was a) the total score on humanistic items, and b) the total score on all items.

Although the blocking variables could be considered pseudo pretests[63] no specific pretest on organic chemistry was used. The subjects might have been sensitized to the treatment by such a pretest and the generalizability decreased. If the subjects were further subdivided on the basis of some receiving a pretest and others not, the cell sizes would have become too small. If the pretest did not have high reliability there would be no gain in precision due to the pretest.

Assumptions The analysis was robust to violations of the assumption of normality of the independent variables as long as the independent variables were fixed; thus all independent variables were fixed. The analysis was also robust to violations of the assumption of homoscedascity for equal cell sizes and equal cell sizes were guaranteed by the sampling procedure. The independence between groups was maintained to the fullest possible extent by supervision of the subjects while using the programmed instruction and writing the tests. The students did not all write the units simultaneously, however, but treatment groups were dispersed throughout classes.

Hypotheses Tested In the study of learning as a function of value orientation the aspects which were of potential importance in personalizing instruction were stated in the null form as an operational basis for the analysis of the experimental data.

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[63]Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, (Chicago: Rand McNally and Company, 1966), 26.

For this purpose it was assumed there would be:

A. No differences in measured learning due to treatments.

B. No differences in measured learning due to levels of humanistic value orientation.

C. No interaction between treatments and levels of humanistic value orientation.

D. No interaction between treatments and levels of chemistry grade.

E. No interaction between levels of chemistry grade and levels of humanistic value orientation.

Analysis

The fixed effects factorial design was employed to permit significance tests for all main effects and interactions of interest. In order to analyse the data the Millman Glass Rules[64] were used to determine the sum of squares expressions and the F-test ratios. The data was then analysed by three way analysis of variance separately for both the humanistic items scores and the total scores. The main effects and interactions were then rejected or not at the 0.05 level of significance using an F-test. The cell means of interactions found significant were examined and graphed to facilitate interpretation.

III. SUMMARY

A Chemistry Preference Evaluation Instrument of 24 sets

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[64] Jason Millman and Gene V. Glass, "Rules of Thumb for Writing the ANOVA Table," The Journal of Educational Measurement, 4 (1967), pp. 41-51.

of alternative statements was developed for the purpose of the study. Each set of alternatives with the instrument contained one statement which stressed the humanistic aspect of chemistry, another the theoretical aspect and a third the technological aspect of a particular chemical phenomenon or fact. The content validity of the categorization was established by the responses of a panel. Differences in the mean scores of engineering science students and theology students for the theoretical and humanistic value orientations supported the construct validity of the instrument. The reliability coefficients were: humanistic 0.85, 0.78; theoretical 0.90, 0.85; technological 0.77, 0.72 for students and teachers respectively. All these reliability coefficients were significant at the .001 level.

All 120 students enrolled in grade twelve chemistry at secondary school A in London, Ontario comprised the population and sample of students. In like manner, 39 teachers employed by the London Board of Education to teach chemistry comprised the teacher population and sample. The Chemistry Preference Evaluation Instrument was administered to both groups in the process of the study.

The relationship of student and teacher characteristics to measured levels of chemistry value orientation was examined and the mean scores of students and teachers on the humanistic, theoretical and technological value orientations were compared.

To study learning as a function of value orientation a fixed effects factorial design was used where the subjects were blocked into three levels on the humanistic value orientation score and two levels on their chemistry grade. The three treatments con

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consisted of three types of introductions, humanistic, technological and placebo, to each of five programmed units on organic chemistry. The dependent variables were a total on all 59 test items and a total on the 23 humanistic items. The analysis of variance was used to test for main effects and interactions.

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CHAPTER IV

RESULTS

The value orientations of both the student and teacher samples towards the humanistic, theoretical and technological aspects of chemistry were measured using the Chemistry Preference Evaluation Instrument. Relationships between characteristics such as student intelligence or number of years teaching experience and value orientations were examined for students and teachers. In addition, the three value orientations of teachers and students were compared using a t-test. As the introductory passages to the programmed units were oriented towards different values, the effect of these passages on measured learning was also investigated using a fixed effects factorial design.

I. VALUE ORIENTATIONS

Students

Intelligence and Value Orientations Hypothesis: There was no correlation between the measured student intelligence, as recorded in the Ontario School Record files, and the humanistic, theoretical and technological value orientations, respectively, as measured on the Chemistry Preference Evaluation Instrument.

The correlation coefficients for measured intelligence and the humanistic, theoretical and technological value orientations were 0.00, -0.14 and 0.08 respectively. Therefore the hypothesis that there was no correlation between measured intelligence and the humanistic, theoretical and technological value orientations could not be rejected.

Academic Averages and Value Orientations Hypothesis: There was no correlation between the student academic averages and the humanistic, theoretical and technological value orientations, respectively, as measured on the Chemistry Preference Evaluation Instrument.

The academic average and the humanistic, theoretical and technological value orientations gave correlation coefficients of 0.13, 0.00 and -0.10 respectively which were not statistically significant. Thus the hypothesis of no correlation between the student academic averages and the three value orientations could not be rejected.

Chemistry Grades and Value Orientation Hypothesis: There was no correlation between student chemistry grades and the humanistic, theoretical and technological value orientations, respectively, as measured on the Chemistry Preference Evaluation Instrument.

The humanistic, theoretical and technological value orientations gave correlation coefficients of 0.09, 0.17 and 0.16 with chemistry grades. Therefore the hypothesis of no correlation between student chemistry grades and value orientations could not be rejected.

Sex and Value Orientations

A. Humanistic. Hypothesis: No difference in the mean humanistic value orientation measured on the Chemistry Preference

Evaluation Instrument for male and female students existed.

The mean humanistic value orientation was 27.20 for male students and 32.42 for female students with t = 3.08 with 119 degrees of freedom. Therefore, the hypothesis was rejected at the .01 level of significance. This was interpreted to mean that female students found the aspects of chemistry related to people and the betterment of the human condition more important than did male students.

B. Theoretical. Hypothesis: No difference in the mean theoretical value orientation measured on the Chemistry Preference Evaluation Instrument for male and female students existed.

The mean theoretical value orientation was 17.44 for male students and 17.13 for female students with t = 0.16 with 119 degrees of freedom. Thus the hypothesis of no difference in the mean theoretical orientation of male and female students could not be rejected.

C. Technological. Hypothesis: No difference in the mean technological value orientation measured on the Chemistry Preference Evaluation Instrument for male and female students existed.

The mean technological value orientation was 26.78 for male students whereas female students received a mean of 22.35 producing t = 3.82 with 119 degrees of freedom. Thus the hypothesis was rejected at the .001 level of significance which was interpreted to mean that male students viewed the technological aspects of chemistry as more interesting and more important than did female students.

Teachers

The Effects of Level of University Chemistry Preparation and Number of Years Teaching Experience on Value Orientations. The two levels of university chemistry preparation employed were more and less than ten university chemistry courses designated as "High Level of Preparation" and "Low Level of Preparation" respectively. The two levels of teaching experience used were less than five years, designated as "Low Level of Teaching Experience", and five or more years, designated as "High Level of Teaching Experience."

The number of teachers within each cell was:

		Level of Teaching Experience	
		Low	High
Level of Preparation	Low	8	10
	High	9	12

The means for the humanistic value orientation were:

		Level of Teaching Experience	
		Low	High
Level of Preparation	Low	21.0	23.6
	High	18.4	20.7

The mean 23.6 was significantly larger than the mean 18.4 at the .10 confidence level. The mean humanistic value orientation was greater for increased teaching experience and a lower level of chemistry preparation. The trends were more evident in Figure 4.1 which showed that teachers with a smaller number of chemistry courses were higher on the humanistic value orientation at both

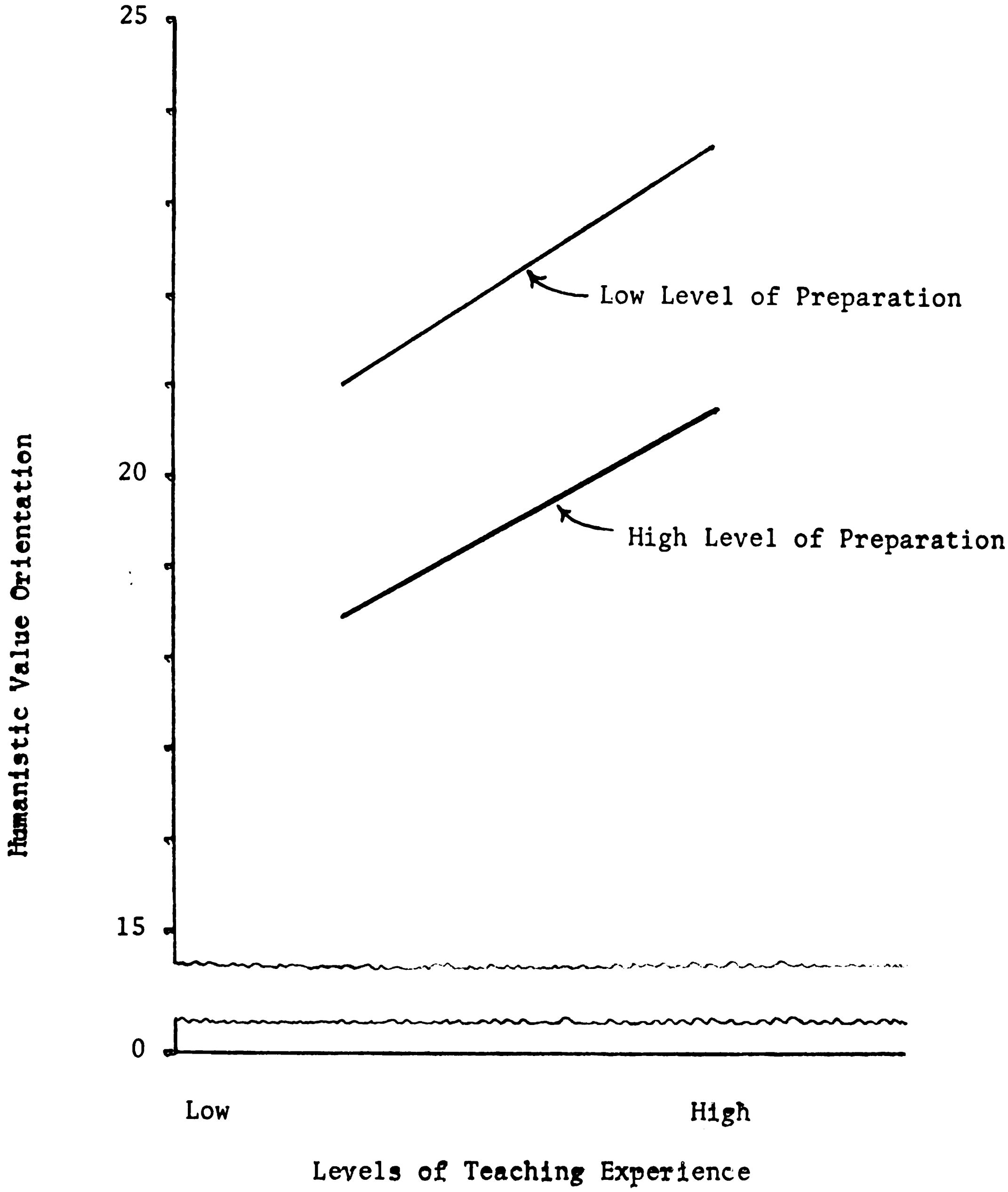


FIGURE 4.1

THE EFFECTS OF TEACHING EXPERIENCE
AND UNIVERSITY CHEMISTRY PREPARATION
ON THE HUMANISTIC VALUE ORIENTATION OF TEACHERS

levels of teaching experience. Similarly, teachers with more teaching experience were higher on the humanistic value orientation at both levels of university chemistry preparation.

The means for the theoretical value orientations were:

		Level of Teaching Experience	
		Low	High
Level of preparation	Low	31.9	24.8
	High	34.9	31.3

The mean 34.9 was significantly larger than the mean 24.8 at the .025 confidence level. The mean theoretical value orientation, measured on the Chemistry Preference Evaluation Instrument was smaller with greater teaching experience but increased with a higher level of university chemistry preparation. It was indicated in Figure 4.2 that teachers with a lower level of teaching experience were higher on the theoretical value orientation than teachers with a higher level of teaching experience, for both levels of university chemistry preparation. Similarly, teachers with a higher level of university chemistry preparation were higher on the theoretical value orientation than teachers with a lower level of university chemistry preparation, for both levels of teaching experience.

The means for the technological value orientations were:

		Level of Teaching Experience	
		Low	High
Level of Preparation	Low	19.1	23.3
	High	17.8	20.0

The mean 23.3 was significantly larger than the mean 17.8 at the .025 confidence level. The mean technological value orientation measured on the Chemistry Preference Evaluation Instrument varied

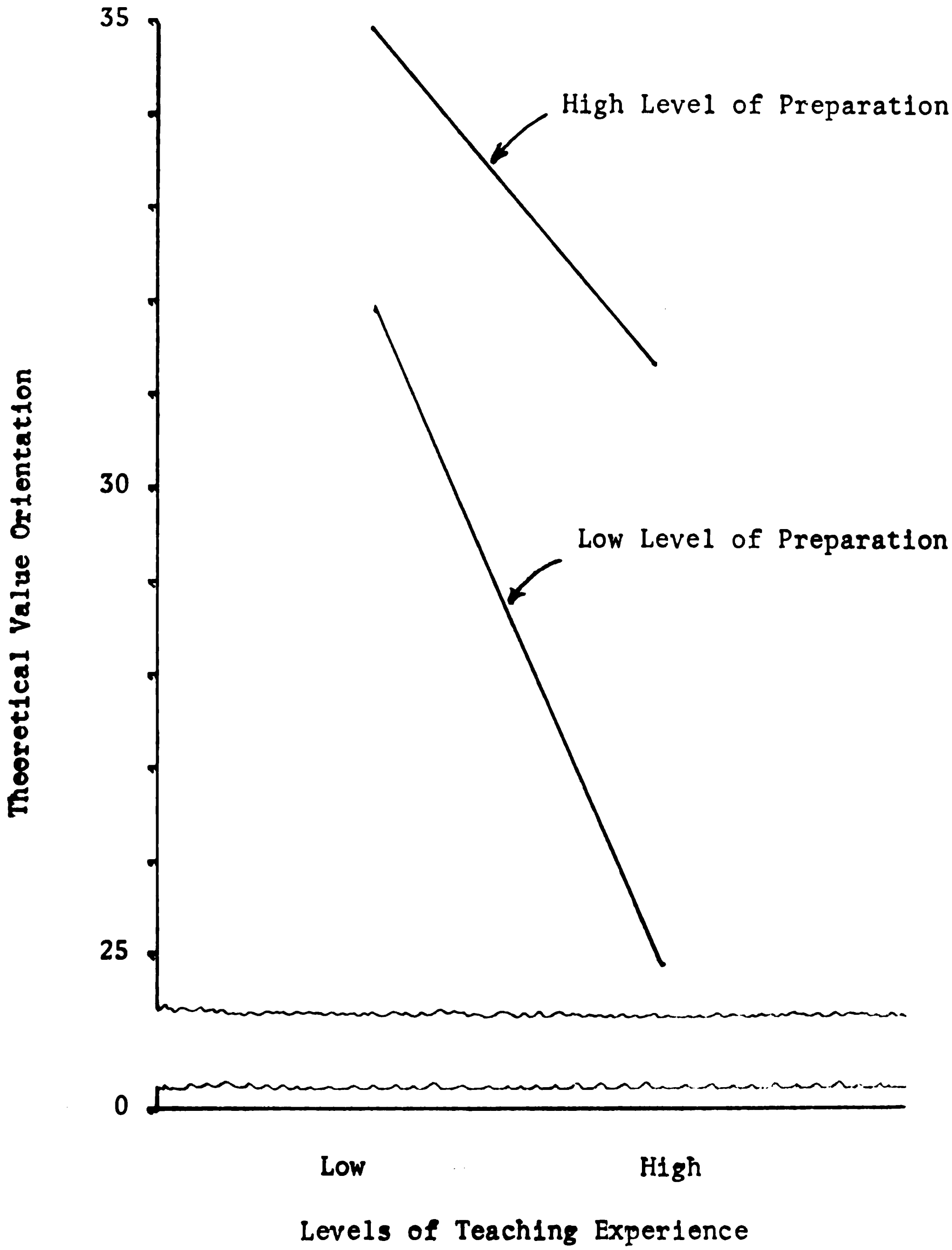


FIGURE 4.2

THE EFFECTS OF TEACHING EXPERIENCE
AND UNIVERSITY CHEMISTRY PREPARATION
ON THE THEORETICAL VALUE ORIENTATION OF TEACHERS

in the same manner as the humanistic value orientation, increasing at the higher level of teaching experience and the lower level of chemistry preparation. As shown in Figure 4.3, the mean technological value orientation was greater at a higher level of teaching experience for both levels of university chemistry preparation. The mean technological value orientation for teachers with a lower level of university chemistry preparation was greater than for those with a higher level of university chemistry preparation but did not appear as influential as teaching experience.

The Effect of Teaching Biology on Value Orientations

A. Humanistic. Hypothesis: There was no difference in the mean humanistic value orientation on the Chemistry Preference Evaluation Instrument between those teachers who were teaching biology at least quarter time and those teachers who were not. Both groups had five or fewer university chemistry courses.

The mean was 25.8 for those teaching biology and 20.8 for those not teaching biology which was not a statistically significant difference. Thus the hypothesis of no difference in the mean humanistic value orientation between those teachers who were teaching biology at least quarter time and those teachers who were not could not be rejected.

B. Theoretical. Hypothesis: There was no difference in the mean theoretical value orientation on the Chemistry Preference Evaluation Instrument between those teachers who were teaching biology at least quarter time and those who were not. Both groups had five or fewer university chemistry courses.

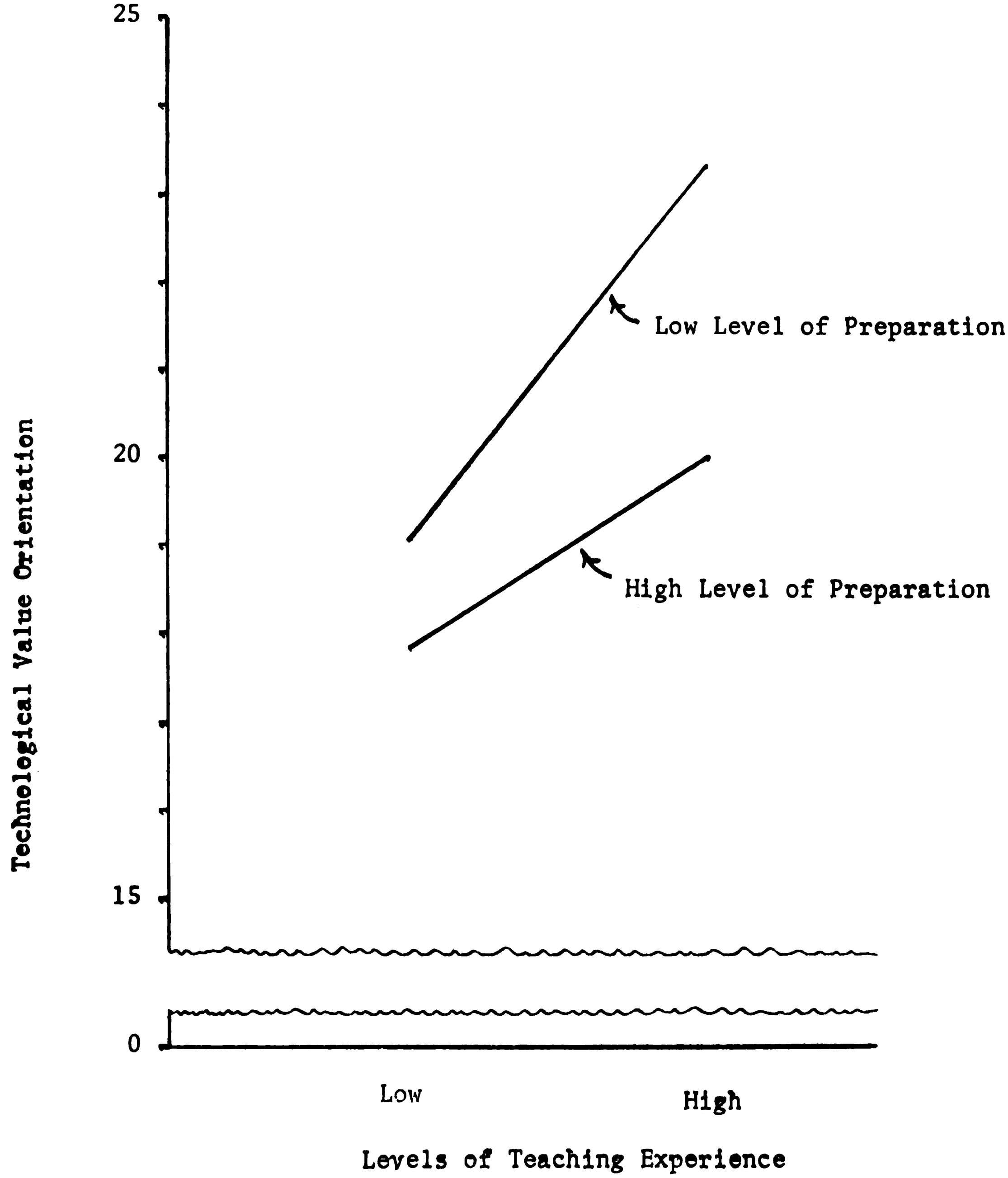
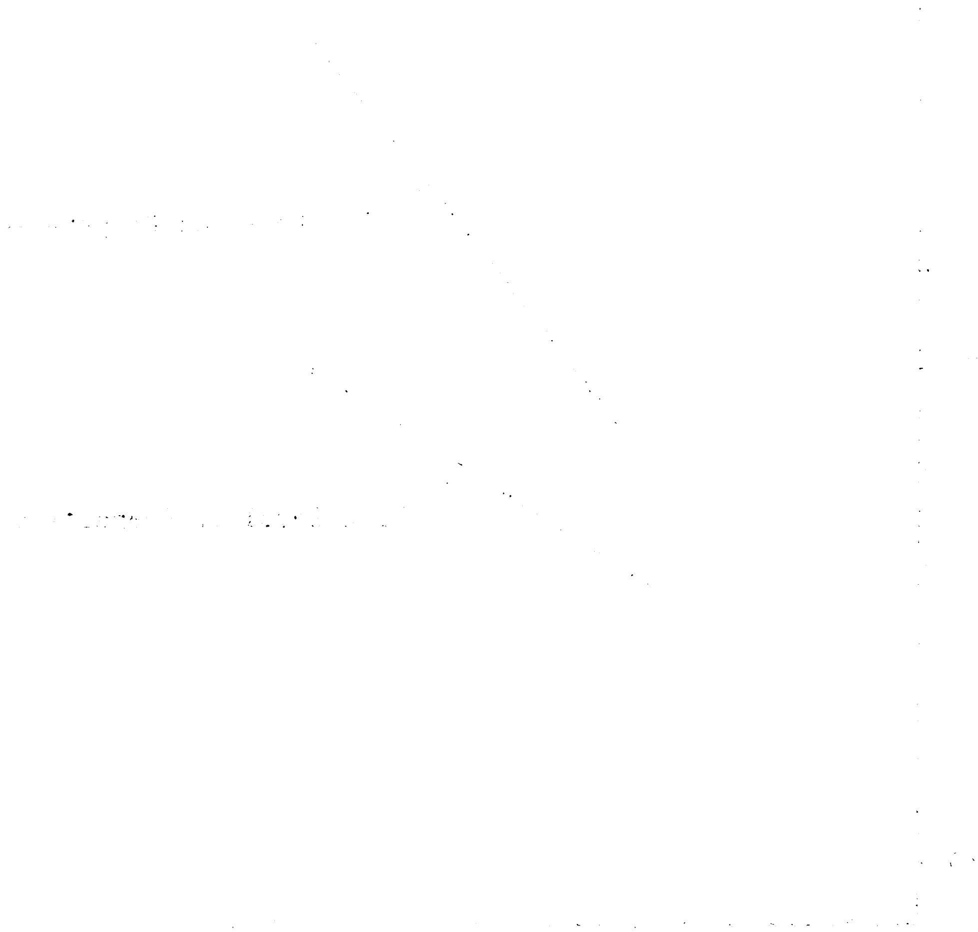


FIGURE 4.3

THE EFFECTS OF TEACHING EXPERIENCE
AND UNIVERSITY CHEMISTRY PREPARATION
ON THE TECHNOLOGICAL VALUE ORIENTATION OF TEACHERS



The mean was 21.3 for those teaching biology and 32.3 for those not teaching biology at least quarter time.

The hypothesis was rejected at the .02 confidence level. This was interpreted to mean that for teachers with equivalent university chemistry preparation, those who were teaching biology did not view the theoretical aspects of chemistry as important or interesting as did those teachers who were not teaching biology at least quarter time.

C. Technological. Hypothesis: There was no difference in the mean technological value orientation on the Chemistry Preference Evaluation Instrument between those teachers who were teaching biology at least quarter time and those teachers who were not. Both groups had a maximum of five university chemistry courses.

The mean was 24.8 for those teaching biology and 18.9 for those not teaching biology at least quarter time.

The hypothesis was rejected at the .06 confidence level. This was interpreted to mean that for teachers with equivalent university chemistry preparation, those who were teaching biology viewed the technological aspects of chemistry as more interesting and important than those teachers who were not teaching biology.

Comparison of Students' and Teachers' Orientations

Humanistic. Hypothesis: No difference in the humanistic value orientation measured on Chemistry Preference Evaluation Instrument existed between chemistry students and chemistry teachers.

The mean was 30.1 for students and 21.0 for teachers.

The hypothesis was rejected at the .001 confidence level. This was interpreted to mean that students viewed the aspects of chemistry related to human nature and betterment of the human condition as more important than did chemistry teachers.

Theoretical. Hypothesis: No difference in the theoretical value orientation measured on the Chemistry Preference Evaluation Instrument existed between chemistry students and chemistry teachers.

The mean was 17.3 for students and 30.6 for teachers.

The hypothesis was rejected at the .001 confidence level. This was interpreted to mean that teachers viewed the theoretical aspects of chemistry as much more important than did chemistry students.

Technological. Hypothesis: No difference in the technological value orientation measured on the Chemistry Preference Evaluation Instrument existed between chemistry students and chemistry teachers.

The mean was 26.1 for students and 20.2 for teachers.

The hypothesis was rejected at the .001 confidence level. This was interpreted to mean that students perceived the aspects of chemistry which were related to the production and utilization of material goods as of more importance and more interesting than did chemistry teachers.

II. LEARNING AS A FUNCTION OF VALUE ORIENTATION

The analysis of variance was performed twice, once with the scores obtained on the 23 questions classified as humanistic and once on all 59 questions. The former score was described as the "humanistic subscore" and had a reliability coefficient of 0.75 while the latter score was denoted the "total score" and had a reliability coefficient of 0.88. Both scores were obtained from responses to the tests administered at the completion of each of the five programmed units.

Main Effects due to Treatments

Hypothesis: There was no difference in measured learning on the unit tests due to treatments.

The main effects for treatments were not significant for either humanistic subscores or total scores as shown in the ANOVA Tables. The hypothesis could not rejected for either humanistic subscores or total scores. This was interpreted to mean that the humanistic and technological introductions to the programmed units did not produce a significantly different amount of measured learning than did the placebo introduction received by the control group.

Main Effects for Levels of Humanistic Value Orientation

Hypothesis: There were no differences in measured learning on the unit tests between levels of humanistic value orientation measured on the Chemistry Preference Evaluation Instrument.

The main effects for humanistic value orientations

TABLE 4.1

ANOVA TABLE: HUMANISTIC SUBSCORES

SOURCE	SS	df	MS	F	TABLE F (.05)
T	2	2	1.0	0.36	3.10
C	246	1	246	189	3.95 *
H	12	2	6.0	2.17	3.10
TH	17	4	4.3	1.56	2.50
TC	59	2	29.5	10.7	3.1 *
CH	251	2	125.5	45.5	3.1 *
R:TCH	250	90	2.78		
TCH	101	4	25.25	9.1	2.50 *

* statistically significant

SYMBOLS

T = Treatments

C = Chemistry Grades

H = Humanistic Value Orientation

R = Replications

TABLE 4.2

ANOVA TABLE - TOTAL SCORES

SOURCE	SS	df	MS	F	TABLE F (.05)
T	390	2	195	2.8	3.10
C	2466	1	2466	35.8	3.95 *
H	388	2	194	2.8	3.10
TH	170	4	42.5	0.6	2.50
TC	287	2	143.5	2.1	3.1
CH	439	2	219.5	3.2	3.1 *
R:TCH	6191	90	68.8		
TCH	50	4	12.5	0.7	2.50

* statistically significant

SYMBOLS

T = Treatments

C = Chemistry Grades

H = Humanistic Value Orientation

R = Replications

were not significant as indicated in the ANOVA tables. The hypothesis was not rejected for either humanistic subscores or total scores. This was interpreted as indicating that there was no significant difference in learning for the various levels of humanistic value orientation.

Interaction of Treatments with Humanistic Value Orientation

Hypothesis: There was no interaction between treatments and levels of humanistic value orientation as measured on the Chemistry Preference Evaluation Instrument.

The interaction between treatments and levels of humanistic value orientation was not significant for either humanistic subscores or total scores as indicated in the ANOVA tables. The hypothesis could not be rejected for either humanistic subscores or total scores.

Interaction of Treatments with Chemistry Grades

Hypothesis: There was no interaction between treatments and levels of chemistry grades measured as teacher assigned grades in chemistry for the current year.

The interaction was not significant for total scores as indicated in the ANOVA table. The hypothesis could not be rejected for total scores.

The F-ratio for the interaction of treatments with chemistry grades had a value of 10.7 for humanistic subscores which was significant at the .05 confidence level. The hypothesis was rejected for humanistic subscores at the .05 confidence level.

The cell means for treatments versus level of chemistry grades for humanistic subscores were:

	Level of Chemistry Grades	
	Low	High
Treatment I (humanistic)	10.8	15.0
Treatment II (technological)	12.9	13.8
Treatment III (placebo)	11.3	15.4

In the graph of the cell means, Figure 4.4, it was evident that for students at a high level of chemistry grade treatments one and three, humanistic and placebo introductions respectively, were superior to treatment two, the technological introductions. Conversely treatment two, technological introductions, was best for those students who had received a chemistry grade at or below the median.

Although the interaction between treatments and levels of chemistry grades was not significant for total scores, the graph of these means[65] displayed a similar pattern.

Interaction of Chemistry Grades with Humanistic Value Orientation

Hypothesis: There was no interaction between levels of chemistry grades, measured as teacher assigned grades, and levels of humanistic value orientation measured on the Chemistry Preference Evaluation Instrument.

The F-ratio for the interaction of chemistry grades with humanistic value orientation had values of 45.5 and 3.2 for the humanistic subscores and total scores respectively. These were both significant at the .05 level, thus the hypothesis was rejected for both humanistic subscores and total scores at the .05 confidence level.

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[65]Appendix D, 141.

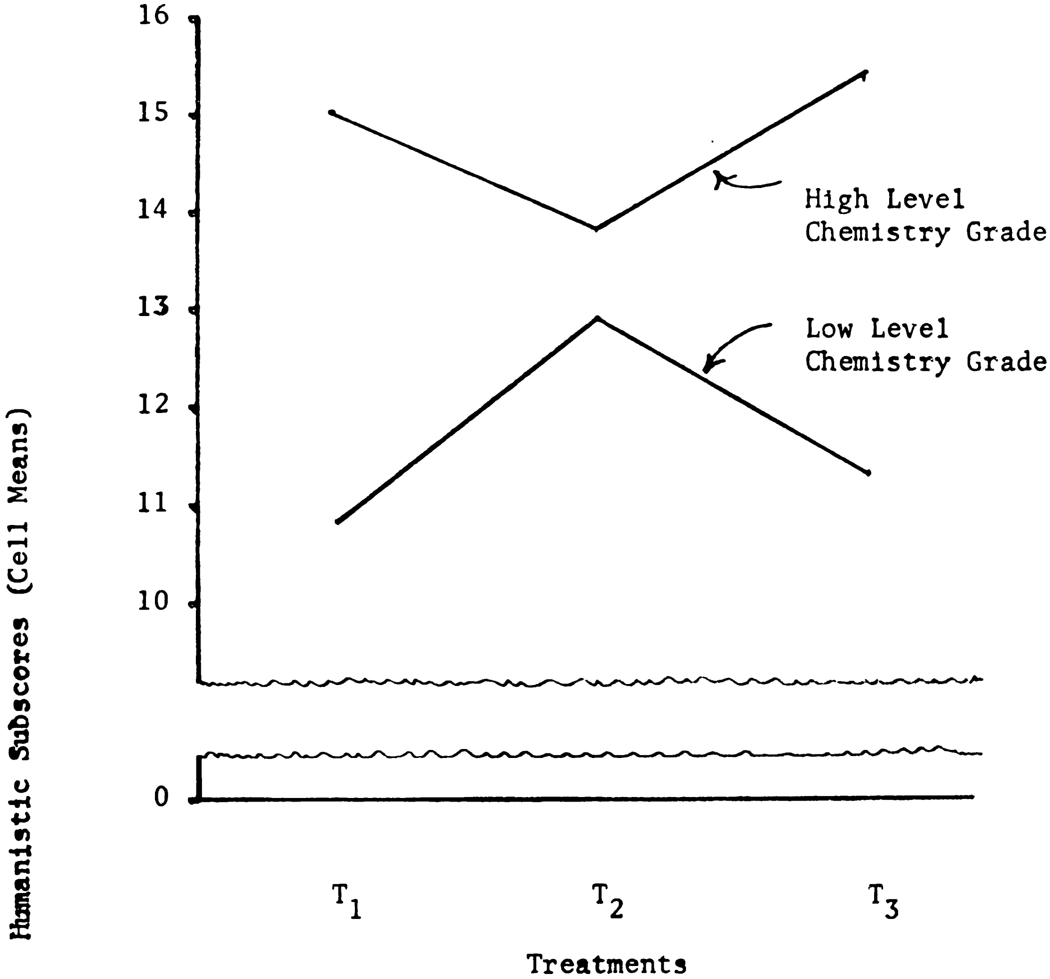

FIGURE 4.4

INTERACTION OF TREATMENTS WITH LEVELS OF
CHEMISTRY GRADE FOR HUMANISTIC SUBSCORES

The cell means for levels of humanistic value orientation versus levels of chemistry grades were:

Humanistic Subscores		Levels of Humanistic Value Orientation		
		High	Medium	Low
Levels of Chemistry Grades	High	15.3	14.9	14.0
	Low	11.6	13.3	11.4

Total Scores		Levels of Humanistic Value Orientation		
		High	Medium	Low
Levels of Chemistry Grades	High	37.0	36.8	36.0
	Low	26.7	28.9	28.4

The graphs of the cell means for these interactions, Figures 4.5 and 4.6, indicated that level of chemistry grades was most prominently related to achievement on the tests for the programmed units. There was little variation in learning, as indicated by both the humanistic subscores and the total scores, for various levels of humanistic value orientation for those students at a high level of chemistry grades. For students at a low level of chemistry grades whose with a medium level of humanistic value orientation obtained the highest scores on both the humanistic subscores and the total scores.

III. SUMMARY

Student value orientations were measured on the Chemistry Preference Evaluation Instrument and found related only to the sex of the student. Female students perceived the humanistic aspects as more important whereas male students viewed the technological

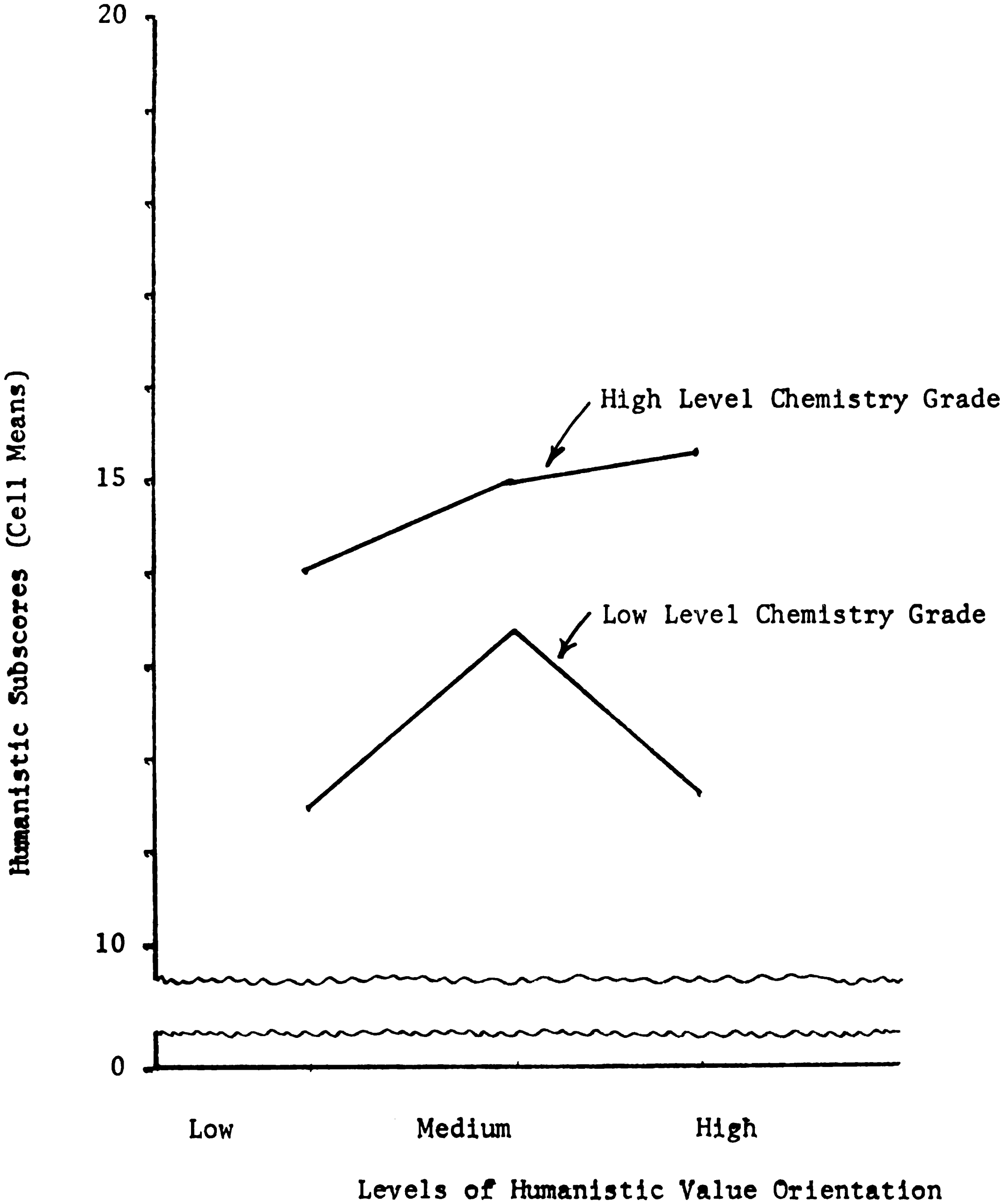

FIGURE 4.5

INTERACTION OF LEVELS OF HUMANISTIC VALUE ORIENTATION
WITH LEVELS OF CHEMISTRY GRADE FOR HUMANISTIC SUBSCORES

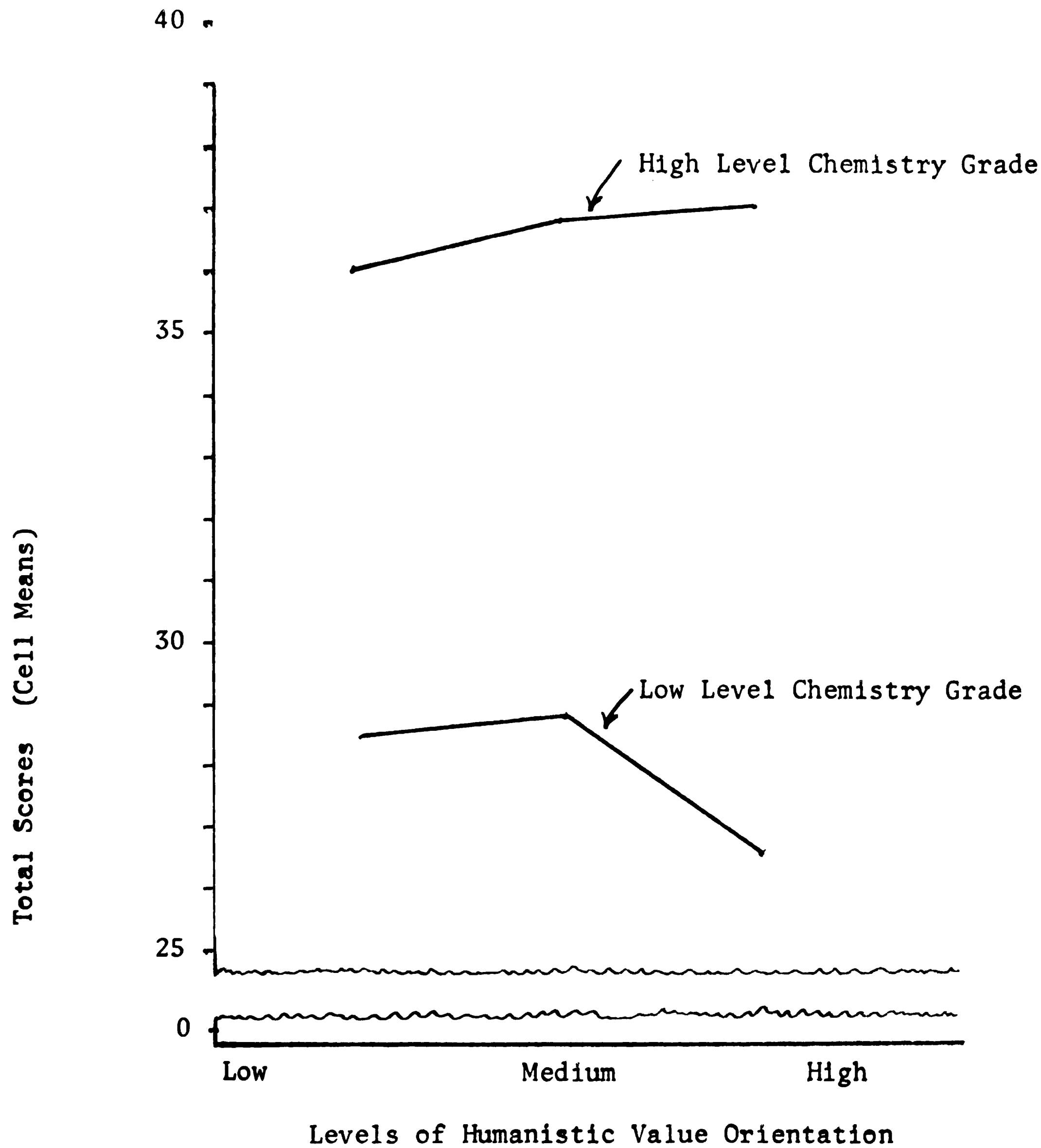

FIGURE 4.6

INTERACTION OF LEVELS OF HUMANISTIC VALUE ORIENTATION
WITH LEVELS OF CHEMISTRY GRADE FOR TOTAL SCORES

aspects of chemistry as more important and more interesting.

Teachers with fewer university chemistry courses and a greater number of years teaching experience viewed the humanistic and technological aspects as more important whereas those with more university chemistry courses and less teaching experience perceived the theoretical aspects as more important. Teachers with a maximum of five university chemistry courses who were teaching biology at least quarter time perceived the theoretical aspects as less important and the technological aspects as more important than did a similarly prepared group of teachers who were not teaching biology.

Teachers viewed the theoretical aspects as significantly more important than did students who viewed the humanistic and technological aspects as more important.

	Teachers	Students
Humanistic Value Orientation	21.0	30.1
Theoretical Value Orientation	30.6	17.3
Technological Value Orientation	20.2	26.1

The difference in the means for teachers and students was significant at the .001 confidence level in each case.

In the experiment to study learning as a function of value orientation the main effects for treatments and levels of value orientation were not significant. The interaction of treatments with levels of chemistry grades was significant for humanistic subscores only whereas the interaction of levels of chemistry grades with levels of humanistic value orientation was significant for both total scores and humanistic subscores. The significant interactions were graphed for further analysis.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

Value Orientations

Recent high school science curricula have placed increasing emphasis on the abstract, rigorous, theoretical aspects of science. This has been attributed by some writers to the influence of research scientists in exercising their beliefs in the superiority of pure or theoretical science to the practical or applied science during the construction of new curricula. Many observers have recognized that these theoretically oriented curricula have been ineffective in stimulating secondary school science students, apparently because the curricula were divorced form the world of reality and thus lacked relevance for average students. It has been suggested that modern students would be more receptive to applications of science in their contemporary technological culture and to concerns such as environmental pollution which affect the individual human. However the relative importance placed by an individual on different aspects of an event or occurrence was a function of the individual's values. A major purpose of this study was to measure the value orientations of students to three aspects of chemistry, the theoretical, the humanistic and technological. The relationship of levels of orientation to selected student and teacher characteristics was examined to discover any patterns of orientation that may have occurred. The value orientations of teachers and students were compared since the value orientations inherent in classroom instruction were partially a function of teacher values.

Procedure and Implementation. A Chemistry Preference Evaluation Instrument of 24 sets of alternative statements was developed containing statements stressing the humanistic, theoretical and technological aspects of particular chemical phenomena or facts. The content validity of the instrument was established using categorization by a panel of five educational and scientific experts. The construct validity was supported by the higher mean scores of the group of 19 Theology students on the humanistic aspects and the 19 Engineering Science students on the theoretical aspects of chemistry with both differences being significant at the .001 level.

The instrument was administered to 120 grade 12 chemistry students in secondary school A in London, Ontario and to 39 chemistry teachers employed by the London Board of Education. The reliability coefficients for the humanistic, theoretical and technological were all significant at the .001 confidence level, for both students and teachers. The relationship of student and teacher characteristics to measured levels of chemistry value orientation was examined and the mean scores of students and teachers on value orientations compared using a t-test.

Results The most significant finding from the examination of student characteristics and levels of value orientation was the orientation of male students to technological aspects of science and female students to the humanistic aspects of the subject.

Teachers with a minimum of university chemistry courses and more years teaching experience viewed the humanistic and technological aspects as more important whereas those with more university chemistry courses and less teaching experience perceived the theoretical aspects of chemistry as most important. Teachers with a maximum of five university chemistry courses but who were teaching biology at least quarter time perceived the theoretical aspects of chemistry as less important and the technological aspects as most important when compared to a similarly prepared group of teachers who were not teaching biology.

The differences in the means of the scores obtained on the Chemistry Preference Evaluation Instrument between students and teachers were all significant at the .001 confidence level.

	Teachers	Students
Humanistic Value Orientation	21.0	30.1
Theoretical Value Orientation	30.6	17.3
Technological Value Orientation	20.2	26.1

Learning as a Function of Value Orientation

Evidence on set induction training, advance organizers and the retention of controversial material supported the general concept that learning was related to the extent to which the learner perceived the material to be learned as meaningful. However this perception would depend on the relative values of the individual. Evidence that learning was a function of value orientation would contribute to achieving the aim of optimizing learning by matching instructional variables with individual learning characteristics.

Procedure and Implementation A fixed effects factorial model was used with the subjects blocked into three levels on the humanistic value orientation score and two levels on their chemistry grades. Three treatments, consisting of humanistic, technological and placebo introductions to each of five programmed units in organic chemistry, were administered during regularly scheduled class periods. The dependent variables were a humanistic subscore on 23 humanistic test items and a total score on all 59 test items. The reliability coefficients; both significant at the .001 confidence level, were .75 and .88 respectively for the test scores. The data was analysed by the procedure of three way analysis of variance and in addition significant interactions were graphed for analysis.

Results There was no significant difference in student learning as a result of the experimental treatments or between the three levels of humanistic value orientation. The interaction of treatments with levels of chemistry grades was significant at the .05 confidence level for humanistic subscores only. The interactions of levels of chemistry grades with levels of humanistic value orientation was also significant at the .05 confidence level for both humanistic subscores and total scores.

II. CONCLUSIONS AND RECOMMENDATIONS

A forced-choice instrument to measure orientations towards the humanistic, theoretical and technological values in chemistry was developed. The instrument produced reliability coefficients significant at the .001 level with both student and teacher samples. Categorization of alternatives by a panel of experts was used to establish the content validity. Although some evidence supporting its construct validity was obtained using Theological and Engineering Science students, construct validity in the area of values remains in question. The Chemistry Preference Evaluation Instrument was satisfactory for this study and would be recommended for further studies of this type where the subjects possessed an elementary understanding of chemistry. There would be merit in obtaining normative data for the instrument for use in comparative studies. It is probable that the development of alternate forms of the instrument would be useful for future studies involving changes in value orientation.

The lack of correlation of measured intelligence, academic average or chemistry grades with the measured value orientations indicated that value orientations could not be inferred from other student characteristics but would require direct measurement. The higher orientation of girls to the humanistic and boys to the technological aspects of chemistry conforms to one of the common stereotypes of sex differences. This raises some question as to whether this difference was an indication of fundamentally different values or merely a reflection of their perception of sexual expectations.

Several factors appeared to simultaneously related to the value orientations of teachers. Blocking the data on two levels of teaching experience and two levels of university chemistry preparation indicated the following:

A. A higher level of university chemistry preparation was associated with a higher theoretical orientation and lower humanistic and technological orientations.

B. A lower level of university chemistry preparation was associated with a lower theoretical orientation and higher humanistic and technological orientation.

C. A higher level of teaching experience was associated with a lower theoretical orientation and higher humanistic and technological orientation.

D. A lower level of teaching experience was assoicated with a higher theoretical orientation and lower humanistic and technological orientations.

These trends must be accepted with reservation since in most cases the differences were statistically significant only when the two factors were combined. No cause and effect relationships could be inferred from the data. While it was probable that exposure to university chemistry courses developed a theoretical orientation it was equally possible that selection of a large number of university chemistry courses was confounded with a high theoretical value orientation. Similarly it was intuitively appealing to conclude that theoretical value orientations decreased with teaching experience, but it is possible that teachers with more teaching experience had undergone a less theoretical university chemistry program than more recent graduates.

Similarly, the teaching of biology was associated with lower theoretical and higher technological value orientations. It could not be inferred that this difference in orientations was a result of teaching biology nor even unique to a teaching assignment in biology since groups with teaching assignments in other subjects, such as physics or mathematics, were not available in the sample.

Students were more highly oriented to the humanistic and technological aspects of chemistry than teachers who were more highly oriented to the theoretical aspects. According to the descriptions of modern curricula as abstract and theoretical, the curricula appeared to coincide more closely with the value orientations of teachers rather than students. The implications for curriculum revision were apparent since students had clearly demonstrated their selection of the humanistic and technological in preference to the theoretical.

Caution must be exercised in inferring that a shift in emphasis to the humanistic and technological values in instruction would result in increased learning. The experiment with five programmed units in organic chemistry failed to show a significant difference in the learning of humanistic material between groups with varying levels of humanistic value orientation. Whether this was due to weakness in the implied relationship between values, interests, motivation and learning or due to multiple factors affecting motivation and learning to the degree that the measures were not sufficiently sensitive to value orientations was not determined.

Observation of the students during administration of the programs gave the impression that individual reactions varied widely depending on personal motivation for success on the tests, and the interaction of learning styles with programmed instruction. The general approval or disapproval for the programmed units underwent reversal for some students during the five units. Some students who reached their normal level of success through extensive study rather than quick initial learning, expressed some frustration at being unable to take the material home for study. All these factors should have been equalized for the various cells since humanistic value orientations were not correlated to intelligence or academic average and subjects were randomly assigned to treatment groups, however with small cell sizes these factors may have contributed to a lack of precision.

The previous arguments were also largely applicable to the failure to detect a significant difference in learning due to treatments. Introductions with more impact on the student would more likely produce a significant difference in learning but if the introductions were quite difficult to make effective they would fail to receive widespread application in any case.

The significant interactions gave information which would be useful in personalizing instruction. For example, the interaction between the levels of chemistry grades and treatments indicated that the humanistic or placebo introduction was superior when learning humanistic material for students at or below the median for teacher assigned chemistry grades. Before instruction was varied on the basis of this interaction or the interaction of chemistry grades with humanistic value orientation, replication experiments would be required to provide further evidence. The interaction of other factors, such as learning styles, would also require investigation to effectively prescribe instruction on the basis of value orientations and other characteristics.

The results of this study have implications for the selection of appropriate curricular materials and the design of programmed instruction in science. It may be feasible for future studies to design curricular experiences in agreement with the measured value orientations of groups of students then measure the resulting effectiveness of these experiences in reaching instructional objectives, particularly those in the affective domain.

Specific contributions of the study to construction of teacher preparation programs for chemistry teachers includes recognition of the variance in value orientations with differing levels of university chemistry preparation. The identification of significantly different student and teacher value orientations adds another dimension to the cognizance of student perspectives developed during teacher preparation. The confirmation of wide variance in value orientations within both pupil and teacher groups supports greater individualization of university course instruction and goals whether content or professionally oriented. A similar instrument might be developed and applied to measure the orientations of pre-service teaching candidates to the humanistic, theoretical and technological aspects of teaching. The experiences in teacher preparation would be modified accordingly. The measurement of orientations before and after such activities as student teaching might also yield valuable insights.

Perhaps the most direct application of the study to practicing teachers should be the increased awareness of the significant differences that exist between student and teacher values which should be considered in planning and executing classroom chemistry instruction.

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APPENDICES

APPENDIX A

RESPONSE FORM AND

CHEMISTRY PREFERENCE EVALUATION INSTRUMENT

APPENDIX A

RESPONSE FORM AND
CHEMISTRY PREFERENCE EVALUATION INSTRUMENT

INSTRUCTIONS

1. This is NOT a test of your knowledge. You cannot give a "wrong" answer. Most of the material will be new to you, but you should understand enough to make reasoned choices.
2. Consider each alternative of equal correctness. Do not try to evaluate the relative correctness of the alternatives.
3. There is no time limit. Please consider each choice quite carefully.
4. From each set of three alternatives, select your first and second choices. These choices should be YOUR PERSONAL PREFERENCES as to the relative value, interest or importance of the alternatives. (Don't let your choice be influenced by what you think someone else would prefer.)

   example: Alternative set #26 first choice c
   second choice b

NAME ______________________________

ANSWERS

Alternative set #	First Choice	Second Choice	
1			
2			
3			
23			
24			

CHEMISTRY PREFERENCE EVALUATION INSTRUMENT

1. The alchemists' chief contribution was:

   a) the beginning of a system of classification of matter;

   b) the preparation of herbs and chemicals with medicinal properties;

   c) development of methods for purifying metals for practical purposes.

2. The equivalence of mass and energy expressed in Einstein's theory of relativity:

   a) is the basis for industrial power from nuclear energy;

   b) was an intellectual achievement which shook the foundations of classical physics;

   c) led to the first atomic bombs, causing great human suffering at Hiroshima and Nagasaki.

3. Nitrous oxide, N_2O

   a) is known as laughing gas, and was used by dentists as an anaesthetic many years ago;

   b) is covalently bonded into a linear molecule, but the covalent bonds can be broken by high temperatures;

   c) is now used as a propellant in commercial whipped cream bombs.

4. Diamonds:

   a) have a romantic mystique which adds more to their value than the brilliant reflection of light accounted for by their chemical structure;

   b) are extremely hard due to the nature of the chemical bonding and crystalline structure;

   c) are important in industrial drilling and abrasion because they are harder than other materials.

5. Chlorine

   a) has chemical characteristics typical of an element which needs only one electron to fill its energy level;

   b) is an essential chemical for industries such as the paper industry;

   c) makes swimmers in the family pool safer from bacteria.

6. The decomposition of silver halide by light:

   a) is the principal chemical reaction upon which the film and photographic industries are based;

   b) illustrates the principle of breaking a chemical bond by adding sufficient energy;

   c) is the principal chemical reaction which permits the originality and dramatic communication of modern photography.

7. Oxygen-hydrogen fuel cells should be investigated more fully because:

   a) the relatively high energy to mass ratio is an important consideration, especially in space research;

   b) the use of such fuel cells would improve the air people breathe in the cities;

   c) a technological breakthrough in fuel cells would revolutionize the automobile industry.

8. Fractional distillation

   a) may most clearly be understood by applying the model of molecules in motion to boiling and condensation;

   b) is used in the preparation of hundreds of consumer products which add to the comfort and health of mankind;

   c) is used for separation and purification in the petroleum industry.

9. The white solid, barium sulphate, is practically insoluble in water.

   a) Patients swallow barium sulphate to clarify X-rays of the digestive tract.

   b) The small extent of dissolving is due to the relatively high attraction of barium for sulphate and their low attraction for water.

   c) Barium sulphate is useful as a paint pigment because of this low solubility.

10. Some atoms of an element give off radiation.

    a) Exposure to this radiation may cause cancer or a change in the hereditary material of a person.

    b) This radiation may be used to detect flaws in metal castings or for automated quality control.

    c) This radiation is released when an extremely small amount of matter is converted into energy.

11. Cellulose and starch both appear in plants, however, humans can digest starch but very little cellulose. The possible human digestion of cellulose would:

    a) likely result from construction of a model of the cellulose molecule and development of theories of cellulose digestion;

    b) lead to the development of new technologies and new industries to produce cellulose-based foods;

    c) make possible the feeding of millions of starving people.

12. Lavoisier was an early French chemist who found that mercury would take a substance out of the air to form a red solid. When the red solid was heated a gas was released.

    a) With a refinement of this experiment Lavoisier was able to refute the phlogiston theory which had retarded the development of better chemical theories.

    b) This experiment launched Lavoisier's career as a famous scientist. His execution on the guillotine illustrates the lack of appreciation for science by the common people of his day.

    c) The removal of oxygen from a metal oxide is a fundamental process to the metal refining industry.

13. The Haber Process makes ammonia from hydrogen and nitrogen.

    a) The use of ammonia as a fertilizer raises food production closer to population requirements.

    b) Ammonia is a basic compound for the fertilizer and explosive industries.

    c) To maximize production of ammonia by this process, temperature, pressure and concentration must be regulated according to the principles of chemical equilibrium.

14. The removal of dissolved materials from sea water;

    a) provides the main source of magnesium for light strong alloys which are important in aircraft construction;

    b) requires a large amount of energy to vaporize the water due to water's extremely strong molecular attractions;

    c) provides water for irrigation to increase food production to fight starvation and malnutrition.

15. Rubber is vulcanized when hot sulphur and rubber are mixed.

a) Charles Goodyear's discovery of vulcanization in 1839 was due more to his faith in himself, and his determination to succeed despite financial hardships, than to his chemical knowledge.

b) The sulphur atoms join together the long rubber molecules with chemical bonds, thus changing the physical and chemical properties.

c) Goodyear's method of vulcanizing rubber was basic to the rubber industry for over 100 years.

16. More gas will dissolve in a liquid as the pressure increases.

a) Carbon dioxide is dissolved in water under high pressure in the production of carbonated beverages.

b) Men who work in a pressurized environment have dangerously increased amounts of nitrogen dissolved in the blood.

c) The amount of a given gas dissolved in a liquid depends on the combined effect of changes for minimum energy and maximum randomness.

17. The tight joining of several atoms of a molecule onto a charged metal atom is called chelation.

a) Chelation can increase the storage time for blood for life-saving transfusions by removing calcium atoms.

b) Chelation is usually specific for each atom because particular angles, atomic sizes and electrical charges are required.

c) Chelation can be used to improve the smoothness and adherence of electroplating.

18. Electrolysis of salt water:

a) produces caustic soda, a basic chemical used in the manufacture of synthetics such as rayon;

b) may release mercury, a dangerous pollutant to man;

c) releases the stronger electron attractor at the negative terminal.

19. You are a chemist who has discovered a new chemical with unique properties. You would like to discover:

a) a theory which would explain these unique properties;

b) an industrial use for this chemical in new products;

c) the medicinal effect of this chemical upon the human body.

20. Combustion may be complete or incomplete depending on the ratio of fuel to air used.

a) The exact ratio for complete combustion of the fuel may be determined theoretically from the balanced chemical equation.

b) The ratio in a car engine is set for incomplete combustion to protect hot metal parts from oxidation.

c) The substances produced by incomplete combustion of gasoline are hazardous to the health of people in large cities.

21. A catalyst is a substance which speeds up a chemical reaction but is only temporarily changed itself.

a) Catalysts play an important role in the chemical industry to increase production efficiency and lower costs.

b) Catalysts speed up reactions by lowering the energy barrier of a reaction or by bringing the reacting particles into collision.

c) Each cell in the human body has hundreds of different catalysts which are essential for life itself.

22. Glass:

a) does not have the atoms in an ordered crystaliine pattern like other solids;

b) has been made by men from the time of Christ to the present from the same materials in the same proportions;

c) is produced by modern industry in many varieties at the rate of about eight million tons per year.

23. Nylon is a synthetic material noted for properties such as strength, toughness and low moisture absorbency.

a) The properties of nylon have made it possible to replace some parts of the human body with nylon substitutes.

b) The properties of nylon may best be understood in terms of its structure as a long chain polymer containing the amide linkage.

c) Due to these many desirable properties industry produces nylon for hundreds of products such as carpets, ropes, tires and clothing.

24. Carbon tetrachloride is a volatile liquid which is a non-conductor of electricity and will not burn.

a) Industry has used carbon tetrachloride as a fire extinguishing agent for electrical fires due to these properties.

b) Carbon tetrachloride must be used with great care because the vapours can cause damage to the liver when inhaled in concentrations as low as 25 parts per million.

c) The properties of volatility and non-conduction may be explained by the symmetry of the carbon tetrachloride molecule.

APPENDIX B

PANEL MEMBERS, VALIDATION AND TEACHER SURVEY

APPENDIX B

PANEL MEMBERS, VALIDATION AND TEACHER SURVEY

PANEL MEMBERS

Miss Sharon McFarlane,

Graduate Student in Education,

Althouse College of Education,

University of Western Ontario,

London, Ontario, Canada.

Mr. Walter Tiessen,

Provincial Consultant in Science,

Ontario Department of Education,

London, Ontario, Canada.

Mr. Gordon L. Walker,

Head of the Science Department,

Strathroy District Collegiate Institute,

Strathroy, Ontario, Canada.

Mr. Dene Webber,

Associate Professor of Curriculum and Instruction,

Althouse College of Education,

University of Western Ontario,

London, Ontario, Canada.

Dr. R. Graham Woolford,

Professor of Chemistry,

University of Waterloo,

Waterloo, Ontario, Canada.

518 Upper Queens Street,

London 16, Ont., Canada,

February 12, 1971.

Dear

As part of the validation of a research instrument I would request your kind assistance to classify the statements on the enclosed preference test. Three categories are defined on the response sheet.

If, in your judgement, a statement is dominated by one of the defined values, then that statement would be categorized as humanistic, technological or theoretical. Since these three values are not entirely independent, it is a matter of your personal evaluation as to whether or not a statement is primarily concerned with, or dominated by, a certain value. If a statement is not dominated by one of these three values, then please categorize that statement as "none of these".

For example, questions 26-28 might be categorized as follows:

QUESTION	HUMANISTIC	TECHNOLOGICAL	THEORETICAL	NONE OF THESE
26	a	b	c	
27	b	a,b		
28	c		a	c

Your careful and prompt attention to this matter would be appreciated, as would any further comment you might wish to make regarding these statements.

Thanking you, I remain,

Yours sincerely,

Peter H. Huston

RESPONSE SHEET

<u>Definition of terms</u>

Theoretical value...concerned with the order and systamatization of knowledge (i.e. the principles, models, systems and hypotheses of science.)

Humanistic value...involves a concern for human nature and improvement of the human condition.

Technological value...involves the production and utilization of material goods.

QUESTION	THEORETICAL	HUMANISTIC	TECHNOLOGICAL	NONE OF THESE
1				
2				
22				
23				
24				

Signature ____________________

Title ____________________

Address ____________________

518 Upper Queens Street,

London 16, Ont., Canada,

March 3, 1971.

Dear

I wrote to you some time ago requesting your assistance in classifying some statements on a preference test. Since I have not heard from you at this time, I am enclosing another copy of the preference test statements, instructions and response sheet.

I would like to have the benefit of your opinion in the validation of this research instrument. Thanking you for your attention to this matter, I remain,

Yours sincerely,

Peter H. Huston

CONTENT VALIDATION FORM FOR UNITS

Introductions:

All the introductions to a particular unit contain some information regarding the unit. The "placebo" attempts to give about the same amount of relevant information as the others. The "humanistic" and "technological" both contain some general organizational information, such as the importance of functional groups. The latter two types differ in the aspect of the unit used for motivation. The "humanistic" appeals to a concern for human nature and improvement of the human condition, whereas the "technological" appeals to interest in the production and utilization of material goods, such as plastics, soap, foodstuffs, dyes and so on. The introductions should be classified according to these descriptions.

Questions:

The questions on each unit simply require classification as "humanistic" or "non-humanistic" on the basis that humanistic involves a concern for human nature and improvement of the human condition.

In order to expedite your classification of the enclosed introductions and questions, a tentative classification has been indicated on the response sheet and you simply indicate whether you agree or disagree.

RESPONSE SHEET UNIT I

SECTION	TENTATIVE CLASSIFICATION	AGREE	DISAGREE
Introduction	humanistic		
Introduction	technological		
Introduction	placebo		
Questions			
1	non-humanistic		
2	humanistic		
3	humanistic		
4	non-humanistic		
5	non-humanistic		
6	non-humanistic		
7	non-humanistic		
8	non-humanistic		
9	humanistic		
10	humanistic		
11	humanistic		
12	non-humanistic		

Signature ____________________

RESPONSE SHEET UNIT II

SECTION	TENTATIVE CLASSIFICATION	AGREE	DISAGREE
Introduction	humanistic		
Introduction	technological		
Introduction	placebo		
Questions			
1	non-humanistic		
2	non-humanistic		
3	non-humanistic		
4	humanistic		
5	non-humanistic		
6	non-humanistic		
7	humanistic		
8	humanistic		
9	non-humanistic		
10	humanistic		
11	humanistic		

Signature ____________________

RESPONSE SHEET UNIT III

SECTION	TENTATIVE CLASSIFICATION	AGREE	DISAGREE
Introduction	humanistic		
Introduction	technological		
Introduction	placebo		
Questions			
1	non-humanistic		
2	humanistic		
3	humanistic		
4	non-humanistic		
5	non-humanistic		
6	non-humanistic		
7	non-humanistic		
8	humanistic		
9	non-humanistic		
10	non-humanistic		
11	non-humanistic		
12	humanistic		

Signature ________________

RESPONSE SHEET UNIT IV

SECTION	TENTATIVE CLASSIFICATION	AGREE	DISAGREE
Introduction	humanistic		
Introduction	technological		
Introduction	placebo		
Questions			
1	non-humanistic		
2	non-humanistic		
3	non-humanistic		
4	non-humanistic		
5	non-humanistic		
6	humanistic		
7	humanistic		
8	non-humanistic		
9	non-humanistic		
10	humanistic		
11	non-humanistic		
12	humanistic		

Signature ____________________

RESPONSE SHEET UNIT V

SECTION	TENTATIVE CLASSIFICATION	AGREE	DISAGREE
Introduction	humanistic		
Introduction	technological		
Introduction	placebo		
Questions			
1	non-humanistic		
2	non-humanistic		
3	non-humanistic		
4	humanistic		
5	humanistic		
6	humanistic		
7	non-humanistic		
8	non-humanistic		
9	non-humanistic		
10	humanistic		
11	non-humanistic		
12	humanistic		

Signature ____________________

518 Upper Queens Street,
London 16, Ontario,
March 8, 1971.

Dear Colleague,

The enclosed set of statements has been developed as part of a research study to determine the preferences of grade 12 chemistry students for various aspects of chemistry. Several classes of students attending secondary school in London have responded to this set of statements.

In order to find out the preferences of grade 12 chemistry teachers in London, I am asking that you please indicate your choices as indicated on the response sheet. If the set of statements is of interest to you, please keep it.

In order to investigate teacher characteristics which may be related to these preferences, I would appreciate your help by answering the enclosed questionnaire. All personal information will be kept confidential. Thank you.

Yours sincerely,

Peter H. Huston

TEACHER CHARACTERISTICS

1) Teacher number ____________________

2) Sex ____________________

3) Age ____________________

4) Year of baccalaureate graduation ____________

5) Degree: (circle) Graduate in Chem.; Honours Chem.;

Honours Science; Engineering; General Science;

General Arts; other (specify) ____________________

6) No. of years teaching to June 1971 ___________

7) No. of years industrial chemistry ___________

8) No. of years work experience, including 6 & 7 __________

9) If you spend more than 25% of your teaching time in a subject other than Chemistry, please indicate the name of that subject. ______________________________

10) Do you presently teach grade 13 chemistry? ____________

11) No. of university courses, approximately of 3 credits each, in chemistry. (Circle one.)

1-3 4-6 7-9 10-12 13-15 over 15

APPENDIX C

TREATMENTS, PROGRAMMED UNITS AND TESTS

APPENDIX C

TREATMENTS, PROGRAMMED UNITS AND TESTS

INTRODUCTION: THE ALKANES

NAME ______________________

CLASS ______________________

Organic chemistry is a fantastically complex, sophisticated area of human endeavor. Due to the unique bonding properties of carbon there are over 500,000 known organic compounds!

Since these compounds make up a great deal of our modern environment, this environment can be better appreciated and utilized for man's benefit by an understanding of organic chemistry. Only by being literate in organic chemistry can you properly fulfill the role of an informed, concerned citizen to ensure that chemistry is directed towards improving the conditions of all the people in our society. You may even wish to play a more direct role in shaping future advances and applications in organic chemistry.

Notice as you work through this unit how organic chemistry affects people: their health, comfort and safety. Look for the patterns of chemical names and the patterns of structure which will help you to digest the details of organic chemistry.

INTRODUCTION: UNSATURATED HYDROCARBONS NAME____________________

CLASS____________________

A crucial aspect of organic chemistry is the fact that an "apparently" small change in the structure of a molecule can drastically change its properties. The presence of more than one shared pair of electrons between two carbon atoms seems like a trivial change in structure. The presence of this extra pair of electrons may determine whether or not a food is potentially dangerous to your health and may dominate the economics of its preparation and thus determine its availability to you.

Look for particular patterns of chemical reactions due to this structure. These reactions have produced a fantastic range of new materials which benefit your life every day. You may have eaten some of these materials for breakfast, had a safer ride to school and be clothed by some at the moment.

Through more complete understanding of these patterns of structure and reactions, man's needs may be even better served in the future.

INTRODUCTION: ALCOHOLS AND ACIDS

NAME________________________

CLASS________________________

"Alcohol" is a word associated with many human emotions: joy and remorse, pride and guilt, friendliness and alienation. Many people do not realize that the work "alcohol" does not specify one compound, but applies to a whole family of compounds. Each member of this family of compounds has a pair of atoms in the same arrangement, called a functional group. This functional group gives the members of the alcohol family similar chemical properties.

It is a curious aspect of human nature that consumption of this functional group, (only two little atoms), has become an emotional, moral and legal issue, especially for consumers under twenty-one years of age.

By careful study of this unit you will learn the functional groups for alcohols and acids and some of their patterns of reaction.

INTRODUCTION: ESTERS

NAME________________________

CLASS________________________

The scene: A chemistry classroom.

Teacher: "Class, what are esters?"

Archie (a football player): "A group of girls with the same name."

Teacher: Mutters a loud groan.

Sydney (an intellectual): "A family of compounds with the same functional group, of course."

Teacher: "Very good, Sydney."

Archie: "I bet only chemists ever meet an ester from one year to the next."

Teacher: "Wrong again Archie. You likely eat esters every day. And you do like to eat."

Archie: "Well is that all esters are good for?"

Teacher: "No. Once you learn how to put a couple of functional groups together to get an ester, you will see that esters may help your girl-friend to look and smell attractive."

Archie: "Functional groups again! I'd like to take apart the next functional group I meet."

Teacher: "If it is an ester group it's easy to take apart. There is one ester you can take apart and get a common product which does more to maintain our everday health than anything else."

Archie: "O.K., O.K. bring on the esters."

INTRODUCTION: ALDEHYDES AND AMINO ACIDS

Name________________________________

Class________________________________

Although all members of the alcohol family are poisonous, the aldehydes are more variable. Some are very toxic and some are part of our daily diet. Close attention to the functional group and its pattern of reactions is still the most efficient way to learn the preparations and reactions of particular aldehydes.

Amino acids and their reactions with one another are at the centre of the exciting new field of molecular biology. Scientists are finding out what happens to actual molecules, some fantastically complex, in the human body. This information may well prove to be the "touchstone" in solving the riddle of cancer and in treating or even preventing hereditary defects. The key to learning the structures and reactions of proteins in the body is the structure and linking of the amino acids.

Perhaps this will be the beginning of a career for you in an area which has such great potential for helping mankind.

INTRODUCTION: THE ALKANES

NAME____________________________

CLASS___________________________

Organic chemistry is a fantastically complex, sophisticated area of learning and application. Due to the unique bonding properties of carbon there are over 500,000 known organic compounds!

Since these compounds make up a great deal of the environment of a modern industrial society, this environment can be better understood and more fully exploited with a knowledge of organic chemistry. There are many industries directly involved in the production of millions of tons of organic compounds each year. Petroleum refining alone has huge plants with delicately controlled reactions producing hundreds of materials. To function effectively in such a technological society an understanding of organic chemistry is an asset. You may even wish to play a more direct role in shaping future advances and applications in organic chemistry.

Notice as you work through this unit how many substances are already familiar to you as consumer products. Look for the patterns of chemical names and the patterns of structure which will help you to digest the details of organic chemistry.

INTRODUCTION: UNSATURATED HYDROCARBONS NAME____________________

CLASS____________________

A crucial aspect of organic chemistry is the fact that an "apparently" small change in the structure of a molecule can drastically change its properties. The presence of more than one shared pair of electrons between two carbon atoms seems like a trivial change in structure. The presence of this extra pair of electrons may determine whether or not an industrial process is feasible. Million-dollar industries are able to make hundreds of different consumer materials only due to the reactions of this extra shared pair of electrons.

Look for particular patterns of chemical reactions due to this structure. Through more complete understanding of these patterns of structure and reactions, chemical technology may produce even more amazing products in the future.

INTRODUCTION: ALCOHOLS AND ACIDS

NAME______________________

CLASS_____________________

"Alcohol" is essential for many industrial processes. Many people do not realize that the word "alcohol" does not specify one compound, but applies to a whole family of compounds. Each member of this family of compounds has a pair of atoms in the same arrangement, called a functional group. This functional group gives the members of the alcohol family similar chemical properties.

Our technologically sophisticated chemical industry requires alcohols produced on a vast scale, both synthetically and by fermentation. The alcohols are either utilized directly themselves or used to prepare other substances such as acids.

By careful study of this unit you will learn the functional groups for alcohols and acids and some of their patterns of reaction.

INTRODUCTION: ESTERS

NAME______________________

CLASS_____________________

Esters are a family of compounds with similar methods of preparation and the same functional group. Many esters occur in nature and may be isolated from their natural sources or synthesized from simpler compounds containing the necessary functional groups. Alone or in skilfull blends, esters are used to produce perfumes and artificial flavorings. These flavorings are necessary for commercial production of such things as candies and beverages. The breaking apart of esters is fundamental to the manufacturing of soap.

The preparation and reaction of esters is best learned and organized by concentrating on the functional groups which combine to form an ester and the structure of the ester group itself.

INTRODUCTION: ALDEHYDES AND AMINO ACIDS NAME________________

CLASS________________

The aldehydes vary widely in their commercial methods of preparation and in their uses. Close attention to the functional group and its pattern of reactions is still the most efficient way to learn the preparations and reactions of particular aldehydes.

Amino acids are essential for animal growth and thus are important in the "food industries". Small amounts of a particular amino acid fed to chickens increases their growth rate. Thus poultry production is made more efficient. A salt of the amino acid, glutamic acid, is produced in large quantities for use as a food additive.

Proteins, composed of many amino acid molecules, are usually the most expensive foodstuff to produce. The key to learning the structures and reactions of proteins is the structure and linking of the amino acids.

INTRODUCTION: THE ALKANES

NAME______________________

CLASS_____________________

Organic chemistry is a fantastically complex, sophisticated area of study. Due to the unique bonding properties of carbon there are over 500,000 known organic compounds.

Crude oil and natural gas serve as the major sources for the hydrocarbons. The crude oil is separated into various components, or fractions, then these fractions are purified. Some fractions must be broken down and then reformed to give marketable substances. Among the simpler components is the group known as the alkanes.

Many of the alkanes have several names, a common or historical name, an early chemical name, and a very systematic name as developed by the International Union of Pure and Applied Chemistry. Principally the systematic names are used in these units. Industry frequently uses the common or historical name.

INTRODUCTION: UNSATURATED HYDROCARBONS NAME____________________

CLASS____________________

Some hydrocarbons contain less than the maximum ratio of hydrogen atoms to carbon atoms due to the presence of more than one shared pair of electrons between two carbon atoms. The presence of these extra electrons between the carbon atoms changes the properties of these hydrocarbons.

These hydrocarbons, called unsaturated hydrocarbons, are produced by the cracking of large molecules obtained from crude oil. The cracking may be effected by heat alone or may require a catalyst as well. These unsaturated hydrocarbon molecules of the proper size increase the octane number of gasoline. The greater the octane number of a gasoline, the less tendency the gasoline has to "knock" or "ping" when the engine is under a heavy load.

INTRODUCTION: ALCOHOLS AND ACIDS NAME____________________

CLASS____________________

"Alcohol" is a word which does not specify one compound but refers to a whole family of compounds with similar structure and properties. The word alcohol has been used to describe the active part of intoxicating beverages ever since the sixteenth century. The word may have come from the Arabic word "al-kuhl" for finely powdered antimony sulphide used to darken eyelids. It is interesting to note, however, that the Arabian alchemists who had been familiar with wine for centuries, never used the word "al-kuhl" in connection with wine.

The word alcohol may be derived from the Latin "spiritus alcalisatus" used for alcohol purified by drying with potassium carbonate.

The word acid comes from the Latin word "acidus" meaning sour, since acidic substances such as lemons taste sour.

INTRODUCTION: ESTERS

NAME________________________

CLASS_______________________

Esters are a family of compounds with similar methods of preparation and the same functional group. Many esters are found in nature in fruits, vegetable oils, animal fats and waxes such as beeswax. All fats and oils are at least slightly unsaturated. The extent of saturation gradually decreases from hard and soft fats such as lard and butter and olive oil to semi-drying oils such as cottonseed oil to drying oils like linseed oil and fish oils. The fish oils are composed from long chain acids with four to six double bonds. The odours of fish oils may be due to this unsaturation. The drying oils form a tough film as they absorb oxygen at the double bonds.

INTRODUCTION: ALDEHYDES AND AMINO ACIDS

NAME_______________

CLASS_______________

The aldehydes vary widely in their methods of preparation and their properties. The familiar catalytic heater produces an aldehyde by the reaction.

Amino acids combine together to form proteins. All living tissue contains proteins, but some tissues, such as flesh or seeds, contain larger amounts. Plants ultimately are the source of all proteins, since only plants can make amino acids from inorganic nitrogen compounds. The plants in turn are helped by nitrite bacteria which change the ammonia of some soil micro-organisms into nitrites. Another type of bacteria change the nitrites into nitrates which the plant can change into amino acids and thus into proteins. The legume plants, with the help of bacteria on their roots, are able to change nitrogen of the air into amino acids.

UNIT I

Well into the nineteenth century compounds which were derived from living organisms were believed to contain a "vitalistic force" due to their plant or animal origins and thus to be uniquely different from compounds originating from non-living sources. These compounds coming from living organisms were said to be "organic" whereas those from non-living sources were called "inorganic". In 1828 Wohler synthesized urea, usually isolated from urine, from ammouium cyanate. This did not have much influence in combating the vitalistic theory, but in 1845 a student of Wohler's named Kolbe synthesized trichloracetic acid proving that an organic compound could be made from its elements without this ______________

vitalistic   force.

Organic chemistry is the study of carbon compounds, according to modern usage.

A carbon atom ($^{12}_{6}C$) has 6 protons, 6 neutrons
and ___ electrons, two in the first energy level
6   and ___ in the second energy level. The outermost
4   four _______________ can be shared with other
electrons   atoms as long as this carbon atom gains the sharing
of 4 other electrons in return. Thus the carbon atom will have 8 shared electrons in its outermost energy level. Each pair of shared electrons is

	called a covalent bond. A covalent bond is made
	of a _________ _________ of electrons.
shared pair	The formation of the compound methane, CH_4,
	would be represented, showing electrons in the
	outermost energy level only, as follows:

$$\cdot\dot{\underset{\cdot}{C}}\cdot \quad + \quad 4\dot{H} \longrightarrow \begin{array}{c} H \\ H\,\ddot{\underset{\cdot\cdot}{C}}\,H \\ H \end{array}$$

	There are ___ pairs of shared electrons which
4	hold the 4 __________ atoms to the ________ atom.
hydrogen	Each hydrogen atom is said to be bonded to the
carbon	_________ atom by a pair of ________ electrons or
carbon	a ____________ bond. The "covalence" of an
shared	atom in a compound is the number of shared pairs
covalent	of electrons or number of __________ bonds
covalent	which the atom has in that compound. Thus in
	methane, carbon has a covalence of ___ and hydrogen
4	a covalence of ___ . Each covalent bond can be
1	represented by a short line. Thus methane would

be $\begin{array}{c} H \\ | \\ H-C-H \\ | \\ H \end{array}$. This type of formula, which shows something of the way the atoms are arranged, is called a structural formula. The covalence of carbon is usually 4, but the bond angles cannot be accurately shown on a two dimensional drawing.

Methane is a light, flammable gas produced by bacterial decomposition of plant and animal matter.

Methane bubbles up from the decaying marsh bottom and the ignition of this gas by lightning probably accounts for superstitious tales of the "will-o-the-wisp." A more modern problem is the explosion of methane produced in a sewer or the explosion of methane released from a coal seam in a mine. Thus _______________ has also been

methane

called "marsh gas", "sewer gas" and "fire damp".

Carbon has the unique characteristic of being able to bond almost indefinitely one carbon atom to another. This accounts for the fact that about 90% of all the known compounds are organic.

Two carbon atoms are bonded together to form the flammable gas ethane, C_2H_6. Thus

```
  H H
  | |
H-C-C-H is the ______________ formula for ethane.
  | |
  H H
```

structural

Each carbon atom has a covalence of ___ and each

4

hydrogen atom has a ___________ of one.

covalence

Similar compounds of hydrogen and carbon, called hydrocarbons, are propane C_3H_8, and butane, C_4H_{10}. In propane there are ___ carbon atoms

3

connected in a chain and there are 4 carbon atoms in a chain in _________. The structural formula

butane

of propane is:

```
  H H H
  | | |
H-C-C-C-H
  | | |
  H H H
```

____

The structural formula of butane is:

$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$ ______________

In both these hydrocarbons, carbon has a __________

covalence — of 4 and hydrogen a ___________ of 1. Looking at

covalence — the structural formulas for ethane, propane, and butane, the carbon atom on each end of the chain is bonded to ___ hydrogen atoms, whereas a carbon

3 — atom from the inner part of the chain is bonded to ___ hydrogen atoms. Therefore a general struc-

2 — tural formula for this family or series of compounds is $H-\underset{H}{\overset{H}{C}}-(CH_2)_n-\underset{H}{\overset{H}{C}}-H$. Notice that each carbon atom has ___ hydrogen atoms plus an extra

2 — hydrogen atom at each end. Thus if there is n carbon atoms there will be 2n hydrogen atoms plus 2 hydrogen atoms for the end carbon atoms. The general formula for this series of hydrocarbons is C_nH_____. This family of compounds

2n+2 — with the general formula, _________, and similar

C_nH_{2n+2} — names, (all end in "ane") is called the alkanes.

Propane is a member of the _________ where

alkanes — n= ___ and 2n+2= ___. Similarly for butane n=___

3,8 — with the formula __________ and for pentane n=5

4 — with the formula _________ . The six carbon

C_4H_{10} — alkane is hexane with formula _________ and

C_5H_{12} — heptane is the seven carbon alkane with formula

C_6H_{14} — ______________. The alkanes can best be re-

C_7H_{16} — membered by learning the number of carbon atoms for each name and deriving the number of hydrogen atoms from the formula C_nH_{2n+2} . Study these 7 alkanes.

Complete the following table:

NAME	# C	# H	FORMULA
METHANE	1	4	
ETHANE		6	
	3	8	
BUTANE			
PENTANE			
	6	14	C_6H_{14}
	7	16	C_7H_{16}

CH_4

2, C_2H_6

PROPANE, C_3H_8

4,10, C_4H_{10}

5,12, C_5H_{12}

HEXANE

HEPTANE

The alkanes are generally unreactive although controlled oxidation has been used with some success to make alcohols and acids.

One of the major requirements of modern man is fuel for heat and for power. Hydrocarbons, from crude oil, are the principal fuel source. The crude oil is separated, broken down and re-formed to give the compounds or mixtures of compounds with the particular characteristics necessary for each use. Propane is sold as a compressed gas for cooking and heating. Natural gas, usually found with crude oil, is made of about 90% methane and 5% ethane. The alkanes with 5 to 10 carbon atoms are liquids at room temperature whereas the larger molecules form progressively thicker liquids until at about 18 carbon atoms they are solids. An alkane of 3 carbon atoms would be a __________, one of 9 carbon atoms a ___________, and one of 30 carbons a _________.

gas

liquid

solid

A wide range of different compounds can be produced by replacing one or more hydrogen atoms of an alkane with atoms such as chlorine or fluorine. If the four hydrogen atoms of methane are replaced by four chlorine atoms, an entirely different compound, carbon tetrachloride, is obtained. Carbon tetrachloride contains _____ carbon atom and ___ chlorine atoms. Methane is an excellent fuel, but carbon tetrachloride is used as a fire extinguishing agent.

1

4

If only 3 of the hydrogen atoms of methane are replaced by chlorine atoms, chloroform, formula ________ , is obtained. The structural formula of chloroform is _____________.

$CHCl_3$

```
 Cl
  \
H-C-Cl
  /
 Cl
```

Chloroform was used extensively in the last century as an anaesthetic to relieve pain during surgery. It is largely replaced with safer drugs at present.

If 2 chlorine atoms and 2 fluorine atoms are used to replace the 4 hydrogen atoms of methane, the compound dichlorodifluoromethane, formula

CCl_2F_2

$$\begin{array}{c} F \\ | \\ Cl-C-Cl \\ | \\ F \end{array}$$

__________________, is produced. The structural formula for dichlorodifluoromethane is

. It is noncorrosive, non-

____

toxic and noninflammable and is used as a refrigerant in the cooling coils of refrigerators and air conditioners under the name of Freon-12.

Thus by changing the atoms bonded to even one carbon atom, dramatic changes in properties and uses occur. It is the possibility for hundreds of thousands of compounds, each with its own structure and properties, that gives organic chemistry almost unlimited potential.

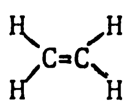
UNIT II

Two carbon atoms can share 1, 2 or 3 pairs of electrons thus forming a single, double or triple covalent bond between the atoms while maintaining a covalence of 4.

If a double bond is present, C=C , the hydrocarbon is called an alkene, and is named by changing the name of the alkane (e.g. ethane) to end in ENE (e.g. eth<u>ENE</u>). The molecular formula for ethene is C_2H_4 and the structural formula is ______________________. Ethene is also known by the name ethylene. The 3 carbon alkene with a name derived from propane is called ____________ with molecular formula ___________. (Note that the alkene always has 2 fewer _______________ atoms than the corresponding alkane due to the double bond.) The structural formula for propene is ____________________.

The alkene with molecular formula C_4H_8 is named _____________ and that with formula C_6H_{12} is named _____________. The formula for pentene is ___________. Draw the structural formula for a compound such as butene as follows:

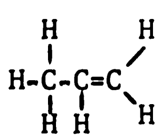
1) put down the correct number of carbon atoms



propene

C_3H_6

hydrogen



butene

hexene

C_5H_{10}

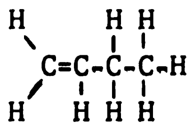
in a chain and join with single covalent bonds. ____________________

C-C-C-C

2) put in a double bond ______________

C=C-C-C

3) complete with hydrogen atoms until each carbon atom has a covalence of 4 ______________



In showing the double bond you may be puzzled as to which 2 carbon atoms it should go between. At first glance there appears to be 3 possibilities: a) C=C-C-C b) C-C=C-C and c) C-C-C=C. Closer examination shows that a) and c) are identical. Different structures with the same formula are called structural isomers. These two __________,

isomers

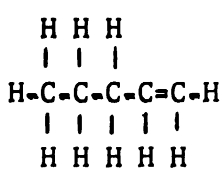
both with formula C_4H_8 but the double bond in different locations, must have names that will distinguish them. This is done by numbering the carbon chain and indicating the position of the double bond. The numbering is started form the end giving the location of the double bond the lowest number possible. Thus 1-butene is the name for structures a) and _____ above, whereas 2-butene

c)

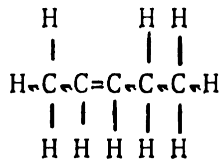
is the name for structure _______. Number the

b)

carbon atoms and name the following:

 ____________________ and

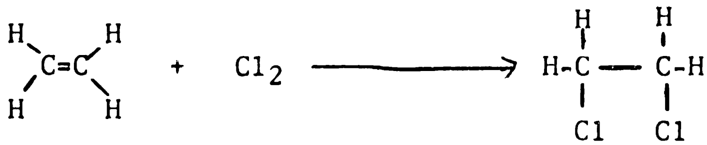
1-pentene

 ________________________ .

2-pentene

The alkenes show much more chemical activity than the alkanes due to the exra pair of electrons at the __________ bond. The most characteristic reaction of alkenes is addition, usually of 2 atoms, at the double bond. Ethene, for example, reacts with chlorine forming the compound 1,2-dichloroethane.

double



Since the chlorine has joined or added on at the __________ bond, the ethene is said to have undergone __________ .

double

addition

Similarly, the addition of bromine to ethene forms 1,2- ____________________ . These two compounds, 1,2-dichloroethane and 1,2-dibromoethane, are used with tetraethyl lead to improve the performance of gasoline in high compression engines.

dibromoethane

Hydrogen can be added to alkenes in the presence of a suitable catalyst such as nickel or platinum. The addition of hydrogen, or the "hydrogenation", of propene produces ____________ . Butane would be formed by hydrogenation of both the isomers ________ and __________ .

propane

1-butene

2-butene

Hydrocarbons which can undergo addition are said to be unsaturated. The unsaturated hydrocarbons can be made more saturated by __________.

addition

Vegetable and animal oils which are unsaturated are often hydrogenated to form solid or semi-solid fats such as shortening or margarine. If hydrogenation is not complete there will be some double bonds remaining and the fat will still be ________.

unsaturated

If there are many double bonds remaining the substance may be described as polyunsaturated. Research has indicated that cholesterol and heart disease may be associated with the consumption of saturated fats. This danger may be reduced by substitution of unsaturated fats in the diet.

An interesting and important type of reaction of unsaturated compounds is combination with other identical molecules. One shared electron pair of the ______________ bond may be used to join atoms

double

of the other molecule in an addition reaction. Ethene, for example, can join with other ethene molecules to form a long chain. This long molecule formed from many single units is called a polymer and the process of joining them together is called polymerization. The joining or ________________

polymerization

of many ethene molecules produces a ____________

polymer

well known as polyethylene or polythene and used extensively for wrapping food. Thousand of synthetic materials such as nylon, rubber, saran and styrofoam which add to the safety, comfort and convenience of our society are made by polymerization. Similarly, the joining or ____________

polymerization — of many propene molecules froms the polymer poly__________.

polypropene — Unsaturated compounds may have 3 shared electron pairs between 2 carbon atoms, forming a triple bond. The simplest member of this family, the alkynes, is $H-C\equiv C-H$ and is called ethyne or acetylene. The names of members of the alkynes, which contain a __________ bond,

triple — are formed by changing the alkane ending of "ane" to "yne". Thus C_3H_4 is the formula for _________

propyne — and C_4H_6 the formula for ___________ . Acetylene

butyne — has a low ignition point and may explode if too highly compressed. It is used in large quantities for welding metals.

UNIT III

A functional group is a group of atoms which occurs in many compounds and gives certain properties to these compounds. The group -OH, for example, is a functional group present in all the compounds known as alcohols.

The simplest alcohol has one carbon atom, like methane, but contains the functional group _______.

-OH

The formula for this alcohol is CH_3OH with structural formula ______________. Alcohols are named by two methods: 1) the "e" is dropped from the name of the corresponding alkane and the ending "ol" added. (e.g. methanol)

```
  H
  |
H-C-O-H
  |
  H
```

2) the first part of the alcohol is named by changing the "ane" alkane ending to "yl" and is followed by the word alcohol. (e.g. methyl alcohol)

The alcohol derived from ethane is C_2H_5OH with structural formula ___________________ and the names ______________ alcohol and _________ol. Similarly C_3H_7OH is derived from the alkane ____________ and has the functional group ________ and is named __________ alcohol or propanol. Although alcohol formulas resemble the hydroxides, alcohols do not produce the hydroxide ion, OH^-.

```
  H H
  | |
H-C-C-O-H
  | |
  H H
```

ethyl alcohol

ethanol

propane

-OH

propyl

Methyl alcohol was made on a large scale by destructive distillation of wood, a process where dry wood is heated without air so the wood cannot burn and the gaseous products condensed and separated. Thus the common name for methyl alcohol is "wood alcohol". Although all alcohols are poisonous, methyl alcohol is particularly toxic, attacking the optic nerve and causing blindness or even death. At the time of Prohibition the name methanol was more widely used to discourage people from consuming ________ alcohol through misunder-

methyl

standing of the word "alcohol". Large quantities of methanol are used as a solvent and to produce other organic compounds. A compound which is used to produce yet another compound is called a "chemical intermediate". Methyl alcohol is an important chemical ______________.

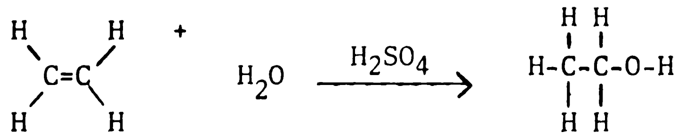
intermediate

Ethyl alcohol, formula ________, has been

C_2H_5OH

produced since ancient times by the fermentation of various food products to produce intoxicating beverages. It was not until the last century that Louis Pasteur showed that a type of catalyst, called an enzyme, produced by yeast cells was responsible for the conversion of sugar into carbon dioxide and ethanol. The flavor of the beverage depends upon small traces of other compounds which come from the foodstuffs such as molasses, corn or potatoes.

Non-beverage ethanol is usually prepared by the following reaction.



In this preparation the alkene __________ undergoes

ethene

________________ of water at the ________ bond

addition

producing ethyl alcohol. Ethanol is widely used

double

as a solvent and a chemical intermediate.

An alcohol can be oxidized to the corresponding acid by an oxidizing agent such as chromic oxide. The oxidation of ethyl alcohol is used to determine the alcohol level in the bloodstream. A standard sized sample of deep-lung air is collected and allowed to react with a standard chromate solution which is a pale yellow. As the chromate oxidizes any alcohol present the solution is bleached. The greater the amount of alcohol present in the blood, the greater the amount of alcohol in the deep-lung sample and the greater the yellow color of the chromate is ______________. The amount of bleaching

bleached

is measured photo-electrically.

The acids produced by oxidation of ___________

alcohols

are called carboxylic acids and contain the carboxyl group, -C=O (with O-H on the C), which is often written -COOH. The systematic name for these _____________ acids is

carboxylic

formed by dropping the letter "e" from the corresponding alkane, and adding the ending "oic". Thus the carboxylic acid containing one carbon atom derived from oxidation of ____________ alcohol is

methyl

_______________ acid. Methanoic acid has the

methanoic

structural formula H-C=O (O-H) and molecular formula ___________________. Because methanoic acid was

HCOOH

at one time derived from red ants, it is frequently named formic acid from the latin word "formica" meaning ant. Methanoic or ___________ acid is

formic

present on the spines of stinging nettles and insect stingers and causes a painful blister on contact with the skin.

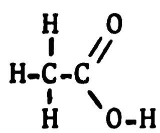
Ethanol is oxidized to form _________ acid,

ethanoic

molecular formula CH_3COOH, which contains the _______________ group and has the structural

carboxyl

formula ___________________. Ethanoic acid is



generally known as acetic acid from the latin word "acetum", meaning vinegar. Household vinegar is a 4 - 5% solution of _________ acid obtained by air

acetic

oxidation of apple cider. Industrially acetic acid is the cheapest organic acid being produced at the rate of several hundred million pounds per year. Its chief use is in preparation of acetate salts and such products as cellulose acetate which is the plastic base for most photographic film.

If the alcohol $CH_3CH_2CH_2OH$ were oxidized, __________ acid with formula __________ would be produced. Butanoic acid, formula __________ would be produced by __________ of __________ alcohol.

Carboxylic acids are generally weak acids, producing a relatively small concentration of hydrogen ions. The only hydrogen atom that can form a hydrogen ion is in the carboxyl group.

$$HCOOH_{(aq)} \rightleftharpoons H^+_{(aq)} + \_\_\_\_\_\__{(aq)}$$

The radical formed when HCOOH, formic __________, loses a hydrogen ion is the formate ion, formula __________. The sodium salt of this acid would be sodium __________ with formula __________.

Similarly the potassium salt of acetic acid would be potassium __________ with formula __________. $CH_3CH_2COO^-$ is the formula for the __________ radical formed when __________ acid loses one __________ ion.

propanoic

CH_3CH_2COOH

$CH_3CH_2CH_2COOH$

oxidation

butyl

$HCOO^-$

acid

$HCOO^-$

formate

HCOONa

acetate

CH_3COOK

propanate

propanoic

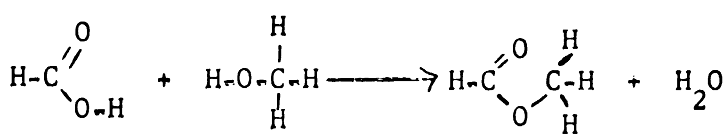
hydrogen

UNIT IV

We have seen that an alcohol, such as $CH_3CH_2CH_2OH$, called ________ alcohol or ________, can be oxidized to produce ________ acid with structural formula ________. The functional group of the ________ is -OH and the functional group of the ________ is -COOH. Although the carboxylic acids produce the hydrogen ion, alcohols do not produce the ________ ion. Nevertheless alcohols and acids do react, producing an ester and water, in a reaction called esterification (e.g. ester-production).

ALCOHOL + ORGANIC ACID ⟶ ESTER + WATER

Let us illustrate the esterification of formic acid and methyl alcohol.

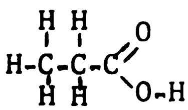


The ester formed by this reaction is methyl formate, the "methyl" coming from ________ alcohol and the "formate" from ________ acid (the "ic" of the acid is changed to "ate"). Thus ethyl propanate would be formed by the reaction of ethyl ________ with ________ acid. Reaction of propyl alcohol

propyl

propanol

propanoic



alcohol

acid

hydroxide

methyl

formic

alcohol

propanoic

with acetic acid would produce the ester

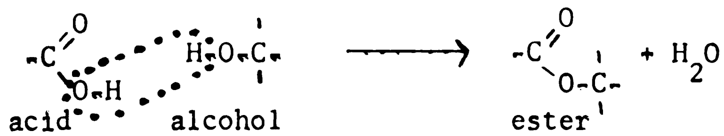
______________________ .

propyl acetate

Alcohols have the functional group _____ and acids the functional group _______. When esterification occurs the site of the reaction is the functional groups of acid and alcohol coming together.

-OH

-COOH



Thus all esters contain the functional group $-\mathrm{C}(=\mathrm{O})-\mathrm{O}-\overset{|}{\underset{|}{\mathrm{C}}}-$, sometimes written as -COOC-, which joins together the hydrocarbon chains of the alcohol and _______. This group, $-\mathrm{COO}\overset{|}{\underset{|}{\mathrm{C}}}-$, is known as the ester linkage. All esters contain the linkage _________. Of the following structural formulas, the only ester is

acid

$-\mathrm{COO}\overset{|}{\underset{|}{\mathrm{C}}}-$

1) $CH_3CH_2-C(=O)-CH_2-CH_3$

2) $CH_3CH_2-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_2CH_3$

3) $CH_3CH_2-\overset{O}{\overset{\|}{C}}-O-CH_2CH_3$

4) $CH_3CH_2-\overset{O}{\overset{\|}{C}}-O-H$

	number _____. Notice that each of these
3)	molecules contains a carbon atom with a doubly
	bonded oxygen atom, $-C(=O)-$, a group called the
	carbonyl group. Molecule 2) most closely
	resembles an ester, but the $-C(=O)O-$, is bonded to
	a carbonyl group, unlike the ester linkage.
	Given an ester formula such as CH_3OOCCH_3,
	how do you identify the part of the ester that
	came from the acid and the part that came from
	the alcohol? Notice that the carbonyl group
	of the ester linkage comes from the __________.
acid	The carbon atom of the carbonyl group <u>always</u>
	has 3 covalent bonds to the oxygen atoms and
	the fourth covalent bond to another carbon atom.
	This carbon atom has <u>no</u> hydrogen atoms bonded
	to it. Thus the portion of the ester coming
	from the acid has a carbon atom with no _________
hydrogen	atoms. Therefore the ester CH_3OOCCH_3 has the
	portion ________ coming from the acid and the
CCH_3 or $OCCH_3$	portion _________ from the alcohol. The acid
CH_3	with 2 carbon atoms is _________ acid and the
acetic	alcohol with 1 carbon atom is _____________
methyl	alcohol. Thus the ester is ___________________.
methyl acetate	The ester $CH_3CH_2COOCH_3$ comes from a ____
3	carbon acid, _____________________ acid and
propanoic	________________ alcohol, thus the ester is
methyl	named _______________________.

methyl propanate

Similarly, the ester with formula $CH_3CH_2CH_2COOH_2CH_2CH_3$ is formed from ___________

butanoic

acid and propyl ___________ with the name of

alcohol

the ester being ________________________.

propyl butanate

Esters occur in nature as an attractive smelling component of ripening fruit. The ester $CH_3CH_2CH_2CH_2CH_2OOCCH_3$, pentyl acetate, resembles the odour of bananas and butyl butan___ the odour of apples. Esters are used

ate

to some extent in synthetic flavors and perfumes but the largest amounts are used as industrial solvents, particularly in the making of lacquers.

If acids containing more than one -COOH group react with alcohols containing more than one -OH group, then each molecule whether alcohol or ______ has at least 2 sites where

acid

an ester linkage can be formed. Thus alcohol and acid molecules can be strung alternately in a long chain joined by _______linkages.

ester

The long molecules produced are a class of polymer called a polyester. Dacron is a tough amazing polyester produced by the reaction of an acid with at least ______ functional

two

groups and an _____________ with at least

alcohol

______ functional groups.

two

Esters will react with sodium or potassium

	hydroxide splitting the ester into the corre-
	sponding alcohol and the sodium or potassium
	salt. Methyl acetate, for example, when heated
	with sodium hydroxide splits into __________
methyl	alcohol and sodium _____________. Similarly
acetate	ethyl formate when heated with potassium
	hydroxide splits into __________ alcohol and
ethyl	potassium ________________. The reaction
formate	between sodium or potassium hydroxide and an
	_______________ is called "saponification"
ester	because it is used to make soap. The ester,
	used to make soap, comes from a very long chain
	acid such as stearic acid $C_{17}H_{35}COOH$ and an
	alcohol called glycerol with the structural
	formula

```
 H H H
 | | |
H-C-C-C-H
 | | |
 O O O
 | | |
 H H H
```

	Since glycerol has ___ alcohol functional groups,
3	the ester will require three molecules of stearic
	acid giving an ester with ___ ester linkages.
3	The saponification of glyceryl stearate with
	sodium hydroxide produces the alcohol __________
glycerol	and the soap sodium ____________. Soap has been
stearate	made by this reaction since ancient times. The
	pioneers in this country used to leach the
	hydroxide from wood ashes then heat it with beef
	fat in a large kettle to make soap.

The glycerol produced by saponification is valuable for making the explosive nitroglycerine used to make dynamite. Nobel amassed a fortune with his manufacture of dynamite and set up the fund for the Nobel prizes.

UNIT V

Just as an alcohol is named by dropping the letter "e" of the corresponding alkane and adding the ending ____, so the family of compounds

"ol"

called the aldehydes is named by adding the ending "al". The functional group of the aldehydes is $-\mathrm{C}\begin{smallmatrix} /\!/\mathrm{O} \\ \diagdown\mathrm{H}\end{smallmatrix}$ which makes the structure of the aldehyde derived from methane $\mathrm{H-C}\begin{smallmatrix} /\!/\mathrm{O} \\ \diagdown\mathrm{H}\end{smallmatrix}$ called ____________.

methanal

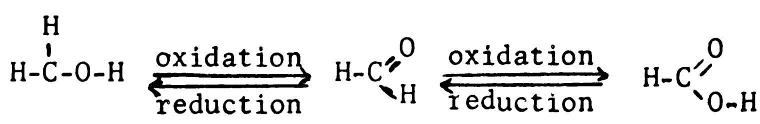
Methanal, like other aldehydes, can be formed either by oxidation of the corresponding alcohol or reduction of the corresponding acid. Thus methanal can be made by oxidation of ________

methyl

alcohol or reduction of ____________ acid.

formic or methanoic

Because methanal comes from formic acid it is also called formaldehyde. Notice the relation of the alcohol, aldehyde and acid.



methanol or methyl alcohol	methanal or formaldehyde	methanoic or formic acid

Formaldehyde has a pungent odour familiar to all students who have dissected biological specimens preserved in a solution of __________.

formaldehyde

Formaldehyde is also used as a fungicide, to treat seeds before planting to increase food production.

Ethanol can be oxidized to the aldehyde ____________ or the aldehyde can be formed by

ethanal — reduction of ______________ acid. The re-

acetic or ethanoic — lationship of ethanal, formula ____________,

CH_3CHO — to acetic acid can be shown by the name _______aldehyde. Acetaldehyde boils at 20°C

acet- — but forms useful solid polymers. Three acetaldehyde molecules polymerize to form "paraldehyde" which has been used medicinally as a sleep producer since late in the last century. Four acetaldehyde molecules polymerize to form "metaldehyde" which is used as a solid fuel for camp stoves.

The aldehyde functional group, ________,

$\text{-C}\begin{smallmatrix} /\!\!/O \\ \backslash H \end{smallmatrix}$ — which also occurs in sugars, is a reducing agent. It will reduce the cupric ion of Fehling's solution to cuprous oxide with a visible colour change. This reduction of Fehling's solution is used as a test for the presence of the ________

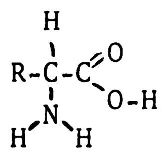
aldehyde — group.

The functional groups encountered so far have been limited to the elements hydrogen, oxygen and ___________. The amino group, $\text{-N}\begin{smallmatrix} /H \\ \backslash H \end{smallmatrix}$,

carbon — is an important functional group found in groups of compounds called amines and amino acids.

The simplest type of amines, the primary

	________________, have the formula $R\text{-}NH_2$ where
amines	R=methyl, ethyl, propyl, butyl, etc. Therefore
	when $R=CH_3$ the amine with formula ___________
CH_3NH_2	named ________________ results. Similarly
methylamine	when R=ethyl the amine formula ________ called
$CH_3CH_2NH_2$	________________ results. Butylamine has the
ethylamine	formula __________ __________.
$CH_3CH_2CH_2CH_2NH_2$	As the name implies, amino acids contain
	both the carboxyl group and the ______ group.
amino	The simpler amino acids have the structural
	formula



where R=H, methyl or other alkyl group.

	Notice that the amino group is bonded to the
	first carbon atom beside the ___________ group.
carboxyl or carbonyl	The formula of the amino acid can more con-
	veniently be written as $R\text{-}CH(NH_2)COOH$. For
	"glycine", the simplest amino acid, R=H and the
	formula is ________________ For the amino
$H\text{-}CH(NH_2)COOH$	acid " alanine" $R=CH_3$ so the general amino acid
	formula ________________ becomes ___________.
$R\text{-}CH(NH_2)COOH$	Amino acids are essential, both for plants
$CH_3CH(NH_2)COOH$	and animals, for many life processes, including
	synthesis of proteins. A protein is formed
	when a very great number of amino acid molecules
	join together or polymerize. If a smaller

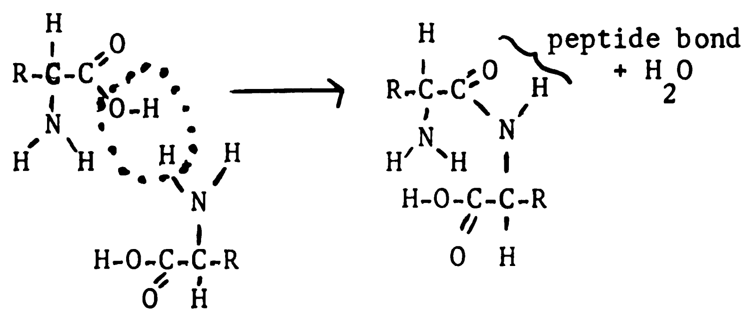
number of __________ acid molecules join

amino

together or __________ giving a molecular

polymerize

weight of less than 10,000, the polymer formed is called a "peptide". The reaction which links amino acid molecules is between the carboxyl group of one molecule and the amino group of the other. This can be shown as:



Notice that the essential part of the linking is the splitting of an oxygen atom and a hydrogen atom from the __________ group with a hydrogen

carboxyl

atom from the __________ group to form a

amino

molecule of water. The carbon of the carboxyl group is bonded to the nitrogen of the amino group in this junction called an amide linkage or peptide bond. The structure of the amide linkage or __________ bond contains 4 atoms

peptide

and can be drawn as __________.

O H
‖ |
-C-N-

If you looked carefully at the equation showing the formation of the peptide bond you may have wondered why the other amino group and carboxyl group did not react. If so your chemical reasoning is correct, two peptide bonds can be formed producing a ring-shaped compound. Ring compounds, containing nitrogen, found in plants are called alkaloids. Many alkaloids have striking effects on the human body. A few of the more familiar ____________ are: nicotine, from the tobacco plant; quinine, from the bark of the cinchona tree used in treating malaria; morphine, which is one of the alkaloids found in poppy seeds. Many primitive peoples have used brews of various plants for treating pain or disease, apparently for the effects caused by the alkaloids present.

alkaloids

UNIT I TEST NAME ____________

Complete the following statements with the most suitable word, words or formula.

1. The number of shared electron pairs which an atom has in a compound is called the ____________ of the atom in that compound.
2. It is the nature of man to attribute phenomena such as the strange flickering lights over marshes to a superstitious creature such as the "will-o-the-wisp", rather than search for a less romantic explanation, such as the burning of ____________ from bacterial decomposition.
3. Many coal miners have been injured and killed when ignition of the hydrocarbon ____________, known to miners as "fire-damp", occurred in a mine.
4. The structural formula of propane is .
5. C_6H_{14} is the formula for ____________.
6. The structural formula of butane is .
7. Alkanes have the general formula ____________.
8. An alkane with 6 carbon atoms per molecule would be in the ____________ state at room temperature.
9. When the hydrogen atoms of methane are replaced by chlorine atoms, a compound is obtained which is used to save lives and reduce property damage as a ____________ ____________ agent.
10. Pain was eased for patients undergoing surgery by use of a compound containing one carbon atom, one hydrogen atom and three ____________ atoms per molecule.

11. A refrigerant used in many air conditioners, to increase human comfort and efficiency during the hot summer months, is the nontoxic compound Freon 12, with the chemical name

____________________ methane.

12. The structural formula for dibromomethane is

____________________________________.

UNIT II TEST NAME ______________

Complete the following statements with the most suitable word, words or formula.

1. Compounds with the same formula but different structures are called structural ________________.
2. The most characteristic reaction of alkenes is ____________.
3. Hexane could be prepared by the hydrogenation of _____________.
4. Housewives save money by buying fats, such as margarine, made by the process of ______________ vegetable oils, rather than buying more expensive animal fats.
5. The structural formula of propene is
   ____
6. Addition of chlorine to 2-butene gives 2,3-________________ ________________.
7. People may reduce the risk of high cholesterol levels and associated heart disease, by replacing animal fat components of the diet with ________________ fats made from vegetable oils.
8. Many foods are much freer from bacterial contamination, reducing the risk to consumers of bacterial infection, due to the packaging of foods in polythene, which is made from the alkene ________________.
9. C_3H_4 is the formula for _____________.
10. In order to avoid serious injury, it is important that welders remember the low ignition point and explosiveness of acetylene, which has structural formula __________________.

11. Safer automobile tires, which reduce highway deaths and injuries, are made from synthetic materials such as nylon, made by a process called ____________________________ from smaller molecules.

UNIT III TEST NAME ________________

Complete the following statements with the most suitable word, words or formula.

1. The structural formula of propanol is ____________________.
2. Consumption as a beverage of wood alcohol, formula ___________, has caused people to go blind or die.
3. In order to reduce the internal consumption of wood alcohol, with its resultant harmful effects on people, the name encouraged for this alcohol was ____________________.
4. Propyl alcohol can be produced by chemical addition of water, aided by sulphuric acid, at the double bond of _______________.
5. The structural formula for methanoic acid is ______________.
6. Methanoic acid can be prepared by oxidation of ________________.
7. $CH_3CH_2CH_2COOH$ is the formula for ____________________.
8. People develop a response of fear, or at least avoidance, of stinging insects due to the painful blister produced by the _____________ on the insect's stinger.
9. Acetic acid is used to prepare ____________ acetate used as a plastic base for photographic film.
10. One molecule of ionized malonic acid, $CH_2(COOH)_2$, would produce ________ hydrogen ion(s).
11. To prepare CH_3COOH you would oxidize the alcohol with formula ______________________
12. In an effort to reduce the injuries and deaths caused by intoxicated automobile drivers, the breathalyzer measures the suspect's alcohol level by the bleaching of _________ solution as it oxidizes the alcohol.

UNIT IV TEST NAME ________________

Complete the following statements with the most suitable word, words or formula.

1. The ester methyl propanate is formed by the reaction of ________________ acid and methyl alcohol.

2. The reaction of formic acid and propanol produces the ester ________________________.

3. The structure of the ester linkage is ____________.

4. The compound with formula $CH_3CH_2CH_2OOCCH_3$ is formed from propyl alcohol and ________________________________.

5. Which of the following is an ester? _________

   a) $CH_3CH_2COOCOCH_2CH_3$

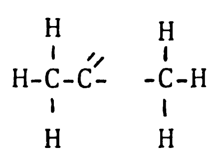
   b) $CH_3CH_2COCH_2CH_3$

   c) $CH_3CH_2COOCH_2CH_3$

6. It is an interesting facet of the psychological conditioning or physiology of man that certain odours, such as the odour of ripening apples due to the ester __________________ are considered pleasant, whereas other odours are considered unpleasant.

7. The average housewife has been relieved of much of the drudgery of ironing by the use of "wash and wear" polyester synthetics made from an acid with at least _______ functional groups.

8. Complete the structural formula for methyl acetate.



9. Ethyl alcohol and sodium formate are produced by the reaction between sodium hydroxide and ____________________.

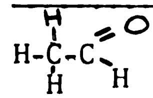
10. Whether his discovery was of overall benefit or harm to mankind was of great concern to Nobel, who discovered dynamite, made form nitroglycerine which was derived from the alcohol ____________________.

11. Saponification of glyceryl stearate with potassium hydroxide produces the soap with the chemical name of ________________.

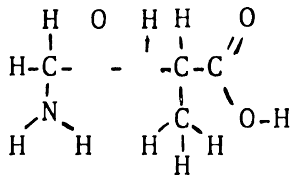
12. Man's ability to use and benefit from that which is not understood is illustrated by the preparation of the hydroxide for saponification from ________________, by the pioneers.

UNIT V TEST NAME ____________________

Complete the following statements with the most suitable word, words, or formula.

1. Methanal may be formed by the oxidation of ________________.
2. The structural formula of ____________ is  .
3. Acetaldehyde may be produced by the reduction of ____________.
4. The yield of crops necessary for human nutrition can be increased by treating the seed with ________________ to kill the fungous diseases.
5. In the last century patients requiring medication to induce sleep were given paraldehyde, a polymer of ________________.
6. Cases of incipient diabetes have frequently been detected early enough to avoid serious consequences by testing the urine for sugar using reduction of the cupric ion by the ________ group in the sugar.
7. Both amines and amino acids contain the functional group with formula ________________.
8. The formula for ethylamine is ______________________.
9. The general formula for the amino acids is ____________.
10. The possibility of reducing hereditary defects in man arises as more is learned about the molecules of hereditary material which are formed by amino acids joined together by ____________ bonds.
11. Glycine and alanine react to eliminate a water molecule and join together to form the structure which is to be completed

below.



12. Quinine is a cyclic compound classed as one of the ___________ which comes from the bark of the cinchona tree and is used to treat malaria.

APPENDIX D

APPENDIX D

DATA MATRICES AND INTERACTION GRAPH

APPENDIX D

DATA MATRICES AND INTERACTION GRAPH

TABLE A.1

DATA MATRIX FOR HUMANISTIC SUBSCORES

	Levels of Chemistry Grades	Levels of Humanistic Value Orientation		
		HIGH	MEDIUM	LOW
Treatment I	High	98	80	92
	Low	59	78	62
Treatment II	High	82	89	78
	Low	76	82	74
Treatment III	High	96	100	82
	Low	74	57	72

TABLE A.2

DATA MATRIX FOR TOTAL SCORES

	Levels of Chemistry Grades	Levels of Humanistic Value Orientation		
		HIGH	MEDIUM	LOW
Treatment I	High	226	198	248
	Low	135	176	159
Treatment II	High	203	227	203
	Low	180	194	171
Treatment III	High	237	237	197
	Low	165	150	183

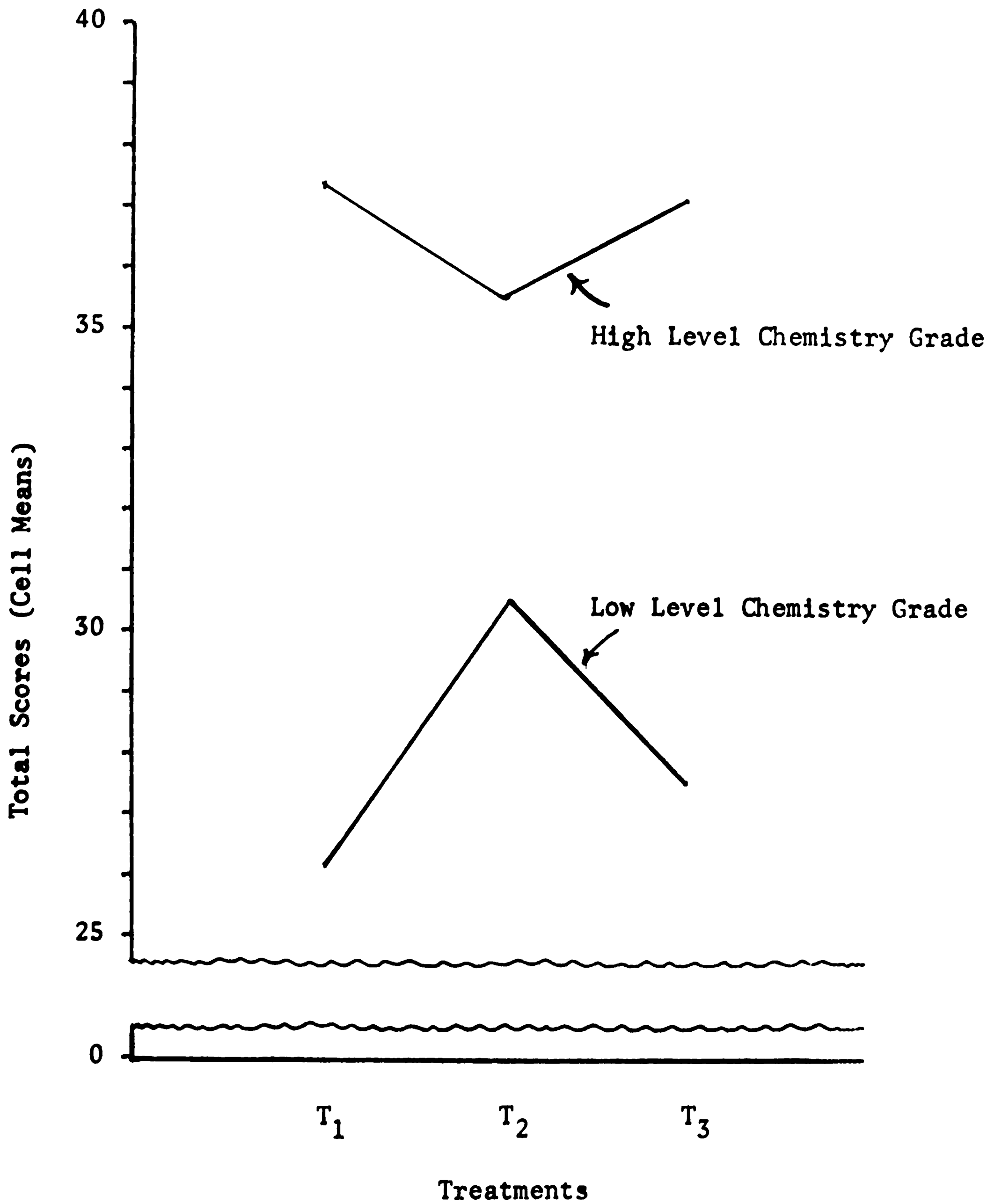


FIGURE A.1

INTERACTION OF TREATMENTS WITH LEVELS OF CHEMISTRY GRADE FOR TOTAL SCORES