THE UNIVERSITY OF ALBERTA

RELATIONSHIPS BETWEEN ADULT STUDENT ATTITUDES AND ACHIEVEMENT

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Abstract

The study examines whether or not a significant and positive relationship exists between

a) attitude to science and achievement in Chemistry.
b) gender and achievement in Chemistry.

The study also examined if there are differences in students attitude to science scores for the variables of grade level, gender, technology of interest and science interest).

The sample consisted of one hundred and seventeen adult students taking Pretechnology at the Northern Alberta Institute of Technology. Students' attitudes to science scores were measured using the Social Implication of Science subscale, Attitude to Scientific Inquiry subscale and the Career Interest in Science subscale of the Test of Science Related Attitudes (TOSRA). Student achievement was expressed as a percent of their mark obtained in Chemistry, Mathematics, Physics and English.

The data analyses included mean, standard deviations, t-tests, ANOVAs and correlations to answer the research questions.

The TOSRA reports high reliability and validity. This data is consistent with the values reported by Fraser (1981).

The study reports no difference in student attitude to science scores for the variables of grade level, gender, technology of interest and science interest. The relationship between gender and achievement in Chemistry shows that females scored slightly higher than males although the differences were not statistically significant at $p = 0.5$ level. Students evaluated positive attitudes to science as indicated by their TOSRA scores as well as reasonably high achievement (means of approximately 70%) for all of the course examinations.

The relationship between Attitude to Science and Achievement in Chemistry indicate that a weak correlation exists. The reported values ranged from as low as 0.06 to as high as 0.22 based on the three subscales used.

In summary, the attitude-achievement link shows a weak correlation and supports the previously published research.

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This thesis is dedicated to my two sons, Nyron Jr. and Ehren. I hope this thesis will help stimulate their interest in Education.

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Background of the Problem

The past decade has seen a major thrust in the design and implementation of various adult education programs. The changing demographics in student population are largely due to shifting economic conditions that have forced adults to return to school. As a result, students have been upgrading their qualifications to meet the demands of industry.

Adults returning to school are faced with a variety of concerns. Their achievement is affected by interests, as well as by physical and psychological states. They tend to learn better when the content of instruction fits their past experience, when continuous feedback for their efforts is given, and when instruction is short and logical. Certain teacher characteristics and teaching methods have been shown to promote the development of positive attitudes in adults (Gorham, 1985; Zemke, 1981). Simultaneously, student achievement is improved (Bloom,1976). The research literature on adult education to date has focused on motivation to learn, curriculum design, and the classroom environment (Zemke and Zemke, 1984). The literature search to date has not shown any studies dealing with adult attitudes toward science. The problem, however, is implementing a program with the various criteria in mind. Unfortunately, lack of support from administration has tended to ignore the problems relating to adult education. There is a need to prepare teachers of adults to teach and deal with the adult student.

Creating a classroom environment conducive to learning is a prerequisite for successful teaching; but the overriding factors that influence a student's need to achieve are the predispositions, beliefs, attitudes and motivations that the student brings to the classroom. Research on student attitudes to science in the elementary grade levels shows that there is a positive correlation between student attitudes and achievement (Bloom, 1976). This trend is consistent in Junior High schools (McMillan and May, 1979) and Senior High schools (Novick and Duvdvani, 1970). However, some of the research findings show a slight positive, slight negative or no correlation between student attitudes and their achievement scores (Wilson, 1983). This inconsistency may be due to the variety of attitude tests available and the type of analyses that are performed to arrive at a relationship between attitudes and achievement (Wilson, 1983).

Gardner (1975) summarizes this concern by saying that researchers use of attitudinal scales have the following problems:

(1) there is a lack of identification and description of a theoretical construct,

(2) the scales reduce the multidimensional attributes of a given phenomena to a single score,

(3) there is very little relationship between the experimental treatment and the scales used.

Some studies have tended to advocate the use of the Likert scales in conjunction with Fraser's Test Of Scientific Related Attitudes (TOSRA), or the attitudinal test of Moore and Sutman (1970) along with anthropological data to give more credibility to the research. Other scales that have been mentioned in the literature include the semantic differential scale (Klopfer, 1969), interest inventories (Murphy, 1970), and anthropological observations (Parlett and Hamilton, 1972). Each scale will measure a unique component of attitudes and will not be comparable to other scales because of the underlying assumptions that are built into each scale.

Attitudes toward science in relation to science achievement vary with gender, age, and grade level (Lawrenz, 1975). Other factors that also relate to student attitudes toward science include: teachers' motivation and characteristics (Lawrenz, 1975), classroom climate (Simpson, 1979), and type of instruction, and teaching methods (Al-Faleh, 1981; Alvarez, 1981). There are numerous studies that look at the above factors in dealing with academic students at the post secondary level but not much has been written about adult student attitudes toward science. This study attempts to determine the relationship between achievement and attitudes of adult students at the Northern Alberta Institute of Technology.

The expression "attitudes toward science" is adopted from Klopfer's affective attitudinal scale. This scale consists of five categories. They are: the manifestation of favorable attitudes toward science and scientists (social implication of science); the acceptance of scientific inquiry as a way of thought (attitudes towards scientific inquiry); the adoption of scientific attitudes; enjoyment of science learning activities; and the development of interests in science outside the classroom. The TOSRA inventory (Test of Science Related Attitudes) will be used in this study. This scale consists of seven sub-scales, with each sub-scale consisting of ten statements. The test scores of the TOSRA also shows good reliability and validity in Australia, America and Britain (Shrigley, 1976).

In summary, achievement in science is influenced by student attitudes to science, their age, educational background, motivation and test anxiety. Other factors that influence achievement are nature of the course content and teacher's behaviour.

Need for the Study

The objectives that are proposed for science education usually include the development of interests, values, attitudes and appreciation. These affective objectives are usually ignored by teachers when planning their classroom activities (Bloom et al., 1971). The perception of educators and the public is that teaching attitudes leads to indoctrination. Also, the lack of proper evaluative instruments have resulted in a deemphasis of the affective domain in science education.

Attitude research over the decades has been chaotic and inconsistent. This is due to the variety of instruments that are available to measure attitudes; the lack of adequate reliability and validity evidence for many of these instruments, the misuse of terms such as attitudes, beliefs and values, scales in which various theoretical constructs are compounded together, and scales which attempt to reduce multidimensional attributes to a single score (Gardner, 1975). This study will specifically investigate the relationship between adult attitudes to science and achievement as well as other factors including gender, age and grade level.

Statement of the Problem

If we are to be successful in teaching adults, then we must look at the predispositions or attitudes that they bring with them to the classroom. How do these predispositions influence their attitudes toward science and in so doing influence their achievement? Is achievement in science influenced by other factors such as gender, age, past educational history, motivation, and career interest?

Definition of Terms

Adult education includes those students that are over 18 years of age and have been out of school for at least one year. This term is also used in the same context as adult upgrading.

The Pretechnology program at Nait is a program of studies that include English, Mathematics, Physics and Chemistry taken for a period of two semesters and is supposed to be equivalent to the High School program of studies.

Attitude is a relatively enduring organization of beliefs around an object or situation predisposing one to respond in some preferential manner (Rokeach, 1968, p. 112).

TOSRA (Test of Science-Related Attitudes). This scale consists of seven parts and a total of seventy Likert-type statements. The three subscales: Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science will be used.

Affective Objectives refer to the development of interests, attitudes, adjustments, appreciation and values.

Purpose of the Study

The purpose of this study is to determine what factors influence student achievement. Specifically, to determine the degree of relationships of student attitudes to science, gender, grade level , career interest and student achievement in Chemistry. Lastly, does student achievement scores bring about a change in attitude towards science or is there a reverse relationship?

The objectives of this study with regard to Pretechnology students at NAIT are:

(1) To measure the student attitudes to science using the TOSRA questionnaire for the total sample and for each group.

(2) To provide an estimate of the test-retest reliability of the TOSRA scale.

(3) To determine differences in student attitude to science on the basis of:

(a) gender

(b) grade level

(c) science interest

(d) choice of technology

(4) To determine the relationship between English, Math, Physics, and Chemistry achievement scores.

(5) To determine differences in student achievement on the basis of gender.

(6) To determine the relationship between attitude to science and achievement.

Delimitation

This study examines one approach to the evaluation of affective objectives using the TOSRA scale. The rationale for using this instrument will be discussed in terms of its usefulness and reliability in Chapter III. No attempt is made to make a comparative analysis with other instruments to measure attitudes or to students from other colleges.

This study deals with an adult population of students taking adult upgrading at NAIT during the first semester. This program includes such courses as English, Mathematics, Physics and Chemistry. No attempts are made to generalize the findings of this research to other colleges that have similar programs.

The present study is confined to three subscales of the TOSRA instead of the seven subscales that are available to measure student attitudes to science. The three subscales chosen in this research were the Social Implications of Science, Attitude to Scientific Inquiry and Career Interest in Science. These subscales were chosen because of the age of the students and students' preconceived notions about science as it relates to society.

The study does not investigate the influence of teacher attitudes, teacher characteristics and teaching methods on student attitudes to science. Although the importance of research in this area is recognized, these topics are beyond the scope of this study.

Limitation

The sample of students is randomly selected to include five of the eight groups that are required to take Chemistry during semester one. These students represent the adult population of students in the Pretechnology program. The present study has limited value with respect to generalizability of the results. The test scores and other demographic data obtained are probably unique for the academic year in which this study was conducted and no attempts are made to make statements concerning the attitudes of adult students in other community colleges.

The Pretechnology students were selected in this study because the majority of these students had not completed a high school diploma. Also, the literature on attitude research has no reference to date of using this group of students. Much research has been conducted to include elementary, junior high, senior high and undergraduate students.

Methodology

This study consists of three parts.

Part one consists of using the TOSRA questionnaire to measure student attitudes toward science. This questionnaire was administered to 120 students (5 sections) on the first day of class. Data also included age, gender, educational background and career interests. During week 7 and week 14 common midterm exams was given. The analysis consisted of descriptive statistics such as means, standard deviations and correlation.

The second part was conducted during week 10 of the program. A questionnaire was given to the students to determine their perceptions on achievement. This questionnaire contains statements on time management, test anxiety, course content and achievement in Math and English.

The final part was completed in the 14th week. Students were administered the TOSRA for the purpose of computing tests-retest reliability and for determining whether a change in attitude occurred between the pretest and postest.

Ethical Considerations

The ethical considerations as stated by the University of Alberta guidelines are adhered to in the design of this study.Written requests were submitted to the Human Resources Department and related administrators at NAIT. The students and teachers were asked to participate on a voluntary basis. The confidentiality of the responses and anonymity of students and teachers are protected and the participants have the option of withdrawing from this study.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

The literature review presented in this chapter is discussed under the following topics: definitions of the affective domain, the affective domain related to science education, factors related to attitude research, techniques used in attitude measurement and methological issues in attitude research.

1. Defining the affective domain

There are several sets of objectives that describe the affective domain. These include description of the development of interests, attitudes, values, appreciations and adjustments (Bloom, et. al, 1956, p. 7). Krathwohl (1964) developed a general classification scheme. This taxonomy defines the affective domain in terms of a valuing system where valuing refers to those activities or objects that are worthy of an individual's attention. The taxonomy has five main categories that describe levels of internalization of values preceding from the awareness of a stimuli to the formation of values associated with that stimuli to the development of values applied to a philosophy of life. Under each category are examples of objectives and test scores for evaluation. However, most of the examples apply to arts as opposed to science. This scheme may not be readily applicable to the definition of affective objectives for science education. Terms such as values, interests, and attitudes associated with the affective domain were not used in the later development of the taxonomy of affective objectives. Krathwohl believes that the variety of meaning associated with these terms were inadequate to serve as a basis for the construction of a continuum.

The "rough-sailing" associated with developing a clear definition of the affective domain has certainly led to its neglect by teachers. Bloom, Hastings, and Madaus (1971) reported that the neglect was in part due to the fear of specifically teaching to achieve affective outcomes being associated with brainwashing and indoctrination. It is with measurement and evaluation that some teachers find further reasons to neglect the affective domain. Some feel that evaluation is not possible and hence affective objectives cannot be legitimized. Others feel that evaluation is not necessary because affective objectives will be attained with the achievement of cognitive objectives.

Nay and Crocker (1970) using the definition of attitude provided by Krathwohl developed an inventory that could be applied to the attitudes of scientists. Historically, attitude has been difficult to operationalize within educational research. However, the research on attitudes to science has been chaotic and confusing. The reasons for this is due to the origins of attitude research.

Shrigley (1983) reviewed the socio-psychological literature in defining attitudes. Early in the 18th century Charles Darwin used the term attitude to describe the physical expression of an emotion in animals in a state of flight.

In the field of psychology and sociology, attitude was first used by Thomas and Znaniecki (1918) to describe the acculturation of Polish peasants in urban America.

Hovland's model (1953) on attitude research is derived from learning theory. His model is based on a persuasive communication to attitude change. He assumes that humankind is rational and we should confront subjects with formal, oral or written communications expecting them to learn attitudes much as they learn life's basic skills.

Lewin's group dynamics model to attitude research stresses the importance of social influence. Central to this model is that man is in need of others, the need to conform and the need for acceptance. This model could best be suited to adolescence. Instead of a structured formal message central to the persuasive communication model, the agent of change in group dynamics is a group norm communicated informally.

In educational research, attitudes are loosely defined in a way that confuses the attitude concept with other psychological concepts such as beliefs, traits, motives, opinions, values and drives. However, the characteristic unique to attitude and the one differentiating it from all other psychological concepts, is its evaluative components. Attitudes consist of three components; the cognitive, behavioral and affective components.

Attitude is a predisposition to respond in some preferential manner with respect to some object or situation (Rokeach, 1968, p. 19). Defining attitude means differentiating it from beliefs, opinions and values whereas attitudes are evaluative, belief is an accompanying cognitive element. The content of a belief may describe the object as true or false, correct or incorrect. Shaw (1967) states that a belief becomes an attitude when it is accompanied by an affective component which reflects the evaluation of the preferability of the object.

An opinion is a verbal expression shaped by attitudes. Values are broader and more encompassing than attitudes. A value may be a core component for a cluster of attitudes. For example, thrift, a value, would support several attitude objects: those toward recycling, quantity buying and comparison shopping. Values are relatively strong and persistent whereas attitudes are learned either actively or vicariously and are subject to change sooner than values.

Shrigley (1983, p. 438), in summarizing the sociological and historical studies on attitudes, has identified key elements to the attitude concept. These are:

1. Attitudes are learned.
2. Attitudes predict behavior.
3. The social influence of others affect attitudes.
4. Attitudes are a readiness to respond.
5. Attitudes are evaluative, emotions are involved.

Shrigley believes that the social-psychological models on attitude research can be modified to fit the needs unique to science education. Hovland's (1953) persuasive communication model and Lewin's group dynamics approaches are recommended. Thus, having a set of principles by which attitude instruments can be designed will eliminate the problem of inconsistency in attitude research.

The Affective Domain Related to Science Education

Klopfer (1976) has alleviated the semantic problems associated with the multiple meanings attached to the term attitude to science. He has provided a comprehensive classification scheme for science education in which six conceptually different categories of attitudinal aims are distinguished. These six categories are:

a) the manifestation of favorable attitudes towards science.

b) Attitudes towards inquiry.

c) Adoption of scientific attitudes such as open mindedness.

d) Enjoyment of science learning experience.

e) Interest in science apart from a learning experience.

f) Interest in a scientific career.

Fraser (1976), in reviewing the literature, selected 1547 stated educational aims that were considered desirable to science education. Of these, 276 were attitudinal aims. Each of the 276 stated aims were then classified using Klopfer's classification scheme. Using this format, Fraser developed his own attitude scale called the Test of Science Related Attitudes (TOSRA). This scale has gained favorable reviews in the science education literature (Shrigley, 1983). The TOSRA is also the focus of this research in accessing student attitudes to science. The selection and validation of the TOSRA will be discussed later in this thesis.

Gardner (1975) and Aiken (1969) identified two major areas of research related to attitudes. These are:

A. attitudes toward scientists and

B. attitudes toward science.

The literature to date indicates that the affective domain related to science education is primarily concerned with attitudes related to science.

A. Attitudes Toward Scientists (Scientific attitude)

The scientific attitude embodies the adoption of a particular approach to problem solving, to assess ideas or information or to make decisions. Gaud and Hukins (1982) identify three components of the scientific attitude. These are:

1) General attitudes toward ideas ano information eg. curiosity, humility, creativity.

2) Attitudes related to the evaluation of ideas and information eg. critical mindedness, objectivity and intellectual honesty.

3) Committment to a particular scientific belief eg. loyalty, trust,

existence of natural causes and effective relationships.
Developing scientific attitudes in students will enable them to have a better understanding of the motive of the scientific process by acting out the role of the scientist and hopefully develop a trend towards rational thought in students.

Nay and Crocker (1970), in a study of scientific attitudes, selected attributes of scientists to include appreciations, interests, attitudes, values, beliefs and adjustments. An example of Nay and Crocker's inventory on interest is presented below:

1. Interest: The motivation for a person to become a scientist and continue to be one.
    - 1.1 Understanding natural phenomena.
    - 1.11 Curiosity.
    - 1.12 Fascination.
    - 1.13 Excitement.
    - 1.14 Enthusiasm.

Using the above scale, Nay and Crocker identified key attributes that scientists possess. Nay and Crocker said that the science teacher was the key to the successfull promotion of such affective attitudes in students.

Gaud (1982) writes that a great deal of effort has been devoted to identifying the nature of the scientific attitude. Most of the work has involved detailed analysis of the writings of scientists, philosophers of science and science educators. The focus of past research has had an empiricist emphasis. There have been few studies done to see if scientists do possess the affective characteristics attributed to them. He further states that scientists display both objectivity and emotionality in their work, instead of the characteristics of rationality, integrity and superior intelligence as was alleged to be the true "nature" of scientists.

B. Attitudes to Science

Gardner (1975a) defines attitudes to science as a learned disposition to evaluate in certain ways objects, people, actions, situations, or propositions involved in learning science (page 2).

Schibeci (1984) summarized the relationship between attitude with other variables. These variables are listed below and discussed in some detail.

1. Cognitive Variables - Achievement, Intelligence, spatial ability.
2. Gender.
3. Structural Variables - grade level

Other variables that are related to attitude to science are personality, school variables, curriculum and instruction. These variables are not discussed because they are not related to the present study.

1. Cognitive Variables

Numerous researchers have looked at the relationship between attitude and achievement. Some authors have shown that achievement influenced attitudes (Eisenhardt 1977). While others have shown that attitude influenced achievement. It is possible that there is a two-way rather than a one-way relationship between these variables. The correlation between attitude and achievement varies from as low as 0.07 to as high as 0.84.

Oliver and Simpson (1988) conducted a longitudinal study on attitude to science and achievement that began in the 1980 - 81 school year and involved a group of 5000 adolescent students in grades 6 through 10. Achievement was determined by school records on the type of courses taken, the grades in the science courses and other standardized measures of achievement. Attitudes towards science was measured using a likert type instrument. Oliver and Simpson concluded that affective behavior in the science classroom are strongly related to achievement. Attitude towards science was not as powerful a predictor of achievement as achievement motivation and science self concept. Simpson (1988) also reported that attitude to science accounted for 20 percent of the variance in achievement in grade 11 and 30 percent in grade 12. This is further substantiated by Kroemer and Walberg (1981).

Wilson (1983) conducted a meta analysis of the relationship between science achievement and science attitude from kindergarten through college.

Wilson used the correlation coefficients for achievement that were reported in science education articles and various statistical methods to determine other contributing variables. Some of the variables that were coded for meta analysis were (a) year of publication; (b) grade-age level of students; (c) ability level of students; (d) if reliability data of the attitude measure was reported; (e) kind of attitude measure used; (f) kind of achievement measured (p. 841).

At the lower elementary level, the mean coefficient is 0.17 but slightly higher in grade 6. At the junior high level, the average correlation reported was 0.21. The senior high level shows a mean correlation of 0.16 and 0.12 at the college level. Generally by grade 6, interests and attitudes are more clearly established so that students that enjoy science perform better in it. At the senior high schools and college levels achievement-attitude correlation drops. This seems to be in part due to the selection and type of courses offered.

The attitude-intelligence link has also been reported as weak although spatial ability and attitude show a positive correlation (Fraser, 1977, 1980). If the results described in the literature are valid then cognitive variables do not appear to be strongly linked to attitudes. However one must be cautious in generalizing on the basis of a small number of studies, inadequate instrumentation and the use of varied attitude objects from study to study such as school science, science interest and science career.

2. Gender

Gardner (1975) stated that "sex is probably the single most important variable related to pupils attitudes to science" (p. 22). Studies have shown that males have more positive attitudes to science than females (Menis, 1983); Wooley (1979). Other studies have reported no statistically significant gender difference attitudes to science (Hamilton, 1982); Selen and Shrigley (1983). These inconsistent conclusions may be the result of grouping the sciences together rather than distinguishing between the physical and biological sciences. Traditionally males are more positive towards the physical sciences than females (Gardner, 1974). Also girls in coeducational schools regarded the physical sciences as "more masculine career fields than the biological sciences". These differences in attitudes are entirely consistent with enrolment patterns and the substantial differences between the sexes suggests that attitudes are more important than cognitive factors in accounting for subject choice. Sociological factors such as career expectations and the belief that women would not succeed as well in the physical sciences may have some impact on the above findings.

Hadden and Johnstone (1982) reported that gender was one of the major influences on student attitudes to science. They said that "in general girls are as keen about science as boys but there are differences associated with the nature of science as they perceive it". Science in many primary schools are male-oriented with boats, cars, parachutes and so on.

Baker (1983) in her study of students attitudes to science, cognitive ability and personality reported that the inconsistency associated with gender difference may be solely due to the turbulent period of childhood and adolescence. That is, the physical and emotional changes experienced by students during this transition period.

Kelly (1986) reported that middle class children had more favorable attitudes to science. She also found that the "smarter" students exhibited greater interest in learning about science. These students were more likely to hold favorable opinions about the social implications of science and about scientists. They were less likely to see science as masculine, and this was particularly true for girls. Kelly also reported that initial attitude to science and gender are strongly related to final attitude with school. Intelligence and attitude show a weaker effect. In attempting to change the masculine nature of science, Kelly used an intervention program that included monitoring classroom interactions, discussing the social implications of science, and promoting curriculum development. The results of this program reported that female attitudes to science were improved.

3. Structural Variables

It appears in general that students attitudes to science decline with increasing grade level Johnson (1981); and Yager (1983). This also seems to correspond to such factors as gender.

Hadden and Johnstone (1983) investigated student attitudes in the transition from primary school to secondary school. Their longitudinal study involved over 1000 students. Attitudes to science were measured in the final year of primary school and again at the end of the first year of high school using the same instrument. They found that during the first year of the pupils' exposure to secondary school science, there was a decline in student attitudes to science. This decline was more pronounced for girls than boys. This finding consistent with the research on gender and attitude to science discussed earlier.

Techniques Used in Attitude Measurement

The techniques used to measure attitude to science are varied. There are a variety of available instruments designed to measure attitudes using a variety of techniques. The techniques which will be discussed, are as follows:

a) differential (Thurstone scales)

b) summated rating (Likert scales)

c) semantic differential scales

d) anthropological data

a) Differential Scales

Differential ("Thurstone-type") scales contain a number of opinion statements, reflecting various positions on an attitude continuum. For example, a scale designed to measure a students attitudes towards school subject, the statement "I am willing to spend my time studying this subject" indicates a positive attitude; "I haven't any definite like or dislike for this subject" indicates a neutral statement and "This subject is a waste of time" is an example of a negative statement (Remmers, 1934).

The scale consists of several of these statements and respondents are asked to select those statements which closely reflects their beliefs. Each statement has a scale value derived from an earlier judging phase in which the judges rate the position of each statement on the attitude continuum. An eleven point rating scale is frequently used and the mean of the scale values are reported for that student. Thurstone's scaling procedures have been widely accepted and extensively used in attitude measurement. Thurstone has developed a sound theoretical and mathematical foundation to support the analytical procedures which are used in the calculation of the scale values. The construction of a scale outlined by Thurstone involves measuring a unidimensional attitude object. A considerable amount of work would be required to develop a scale to measure student attitudes to science and therefore not a practical undertaking in this study. Examples of differential scales that are used in research on attitudes to science are: the Scale to Measure Attitudes Towards any institution (Remmers, 1934); the Attitude Toward any School Subject scale (Silance, 1960); the Thurstone Interest Schedule (Thurstone, 1947).

b) **Summated Rating** (Likert scales)

The summated rating scale employs the use of positive and negative statements with each statement having a weighting associated with it. The most commonly used form is the Likert-type scale. Statements on the Likert scale are followed by two to seven responses, eg. (Yes/No, Approve/Neutral/Disapprove, Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree) and so on. Positive statements are scored from five to one while negative statements are scored in the reverse order. A student's score would be the sum of the individual item scores. Statements are usually piloted to remove any statements that fail to discriminate between respondents at opposite ends of the attitude continuum. The Likert scale is the most popular of the scales that are used in attitude research. Some examples of Likert-type scales are: the Scientific Attitude Inventory (Moore and Sutman, 1970); Interest and Enjoyment in Learning Science (Keeves, 1972); Attitude to Science and Science Lessons (Tisher and Power, 1973) and more recently the Test of Science-Related Attitudes devised by Fraser (1978).

Each of the TOSRA subscales consist of ten statements. An example of a Likert-type statement would consist of a statement "Science - lessons bore me" is used to measure the Enjoyment of Science subscale. The respondent is then marked based on the Strongly Agree ----- Strongly Disagree continuum. Total possible scores for this subscale would range from 10 (highly negative) to 50 (highly positive). Koslow (1973) states that responses of likert items may also be affected by differing meanings by different respondents. Students may assign different meanings to terms such as strongly agree, agree and so on. Shibeci (1982) in attempting to compare the Semantic Differential or Likert instrument noted that the Likert scale clearly indicates their interest and are more sensitive than the Semantic Differential scale. The Likert scale, however, would be limited in assessing a set of concepts to be compared using bipolar adjective pairs such as good/bad. Aikenhead (1988) criticizes the Likert scale as the least accurate when measuring student beliefs on science, technology, and society. He recommends the use of empirically developed multiple choice statements as an alternative method in measuring student attitudes.

c) Semantic Differential Scale

Semantic differential scales were developed by Osgood et al (1957). A word or phrase that is representative of an attitude object (eg. physics lessons; science laboratory) is presented followed by several bipolar adjectives such as (good/bad, interesting/dull, easy/hard). The adjectives lie on opposite ends of the continuum and are assigned a range of values from one to seven. The values obtained are a measure of the respondents attitude towards the attitude object. Factor analysis is then used to distil the responses and show that the adjectives relate to the same dimension. Examples of research involving the use of such scales are Welch (1973) to assess students attitudes to Physics and Robinson (1980) to asses the attitudes of students to "human sciences" course. Heise (1977) states that "too little methodological research is available to decide when semantic differential scale always provide a sensitive a measure of attitudes as is given by traditional scales" (p. 247). Schebeci (1982) believes that the semantic differential scale because of its general format is less overt.

d) Anthropological Data

Parlett and Hamilton (1972) argue for an increased use of social-anthropological models of research in curriculum evaluation and a reduction in emphasis upon agricultural-botanical procedure. Zinberg (1971) studied the attitudes of staff and first-year students in the Chemistry department. Her data gathering included questionnaires, interviews and participant observation (a method used by anthropologists). This allowed her to view the student experience on a personal level, to understand the social interaction between staff and students. Her observations included the growth of apathy, the decline in committment and the widening gap between the values of students and staff.

This methodology provides traditional researchers in this area, an opportunity to employ both quantitative and qualitative methods of analysis. The author did not employ both quantitative and qualitative methods in this study because of the amount of workload involved but would recommend this type of format for a dissertation study.

Of the various scales discussed the Likert scale is reported in 56 studies that are related to attitudes to science. Because of the diversity of scales and techniques used in attitude research it is very difficult to make any generalizations that are meaningful. This is evident by the disparity in research findings in a given area. Some of the other techniques that are used in attitude research are interest inventories, preference ranking, projective techniques and enrollment data. Gardner (1975) and Schebici (1984) and others have addressed the methodological issues that have plagued attitude research. Below is a brief discussion of these issues.

Methodological Issues in Attitude Research

Gardner (1975) discussed the methodological issues that have plagued attitude research and suggests that basic problems stem from poor construction of instruments used to measure attitude. According to Gardner there are five steps involved in the construction of a valid and reliable attitude instrument: definition of the attitudes to be measured, scale construction, trial, appropriate use, and appropriate choice of research design and statistical analysis (1975; page 2).

The instrument that will be used must be related to a single attitude object so that an attitude score is indicative of that specific object. For example an attitude scale entitled Attitude to Science Course at Training

College (Shah, 1962) had the following items.

"I feel that practical work in science must be done in groups".

"I feel that the science course at college is easy".

The above two statements deal with group work versus (presumably) individual work and ease versus difficulty. There is no single construct underlying this scale so that using a summated rating technique to achieve an overall single score would be futile. Likewise if more than one variable is to be measured then each should be specified in advance and the instrument should yield separate scores for each variable.

Item construction and subsequent trial of the instrument should include statistics such as mean, standard deviation, frequency distribution and measures of sensitivity, internal consistency, stability and factor analysis.

Sensitivity refers to the ability of a scale to discriminate among individuals i.e. to show a range of scores for the population and to show low error variance. Internal consistency refers to the tendency of items correlated with one another and with the total scores. This is achieved by estimating the split half correlation coefficient or Cronbach's coefficient alpha.

Stability refers to the tendency of a scale to yield similar scores when applied to the same individuals at different times. This is achieved by doing a test retest correlation.

Haladyna and Shaughnessy (1982), in their review, argue for the use of meta analysis in determining the reliability and validity of attitude research.

The term meta analysis refers to the qualitative synthesis of research for the purpose of integrating the findings and to determine which researchers have used sound experimental procedures in performing their research so that there is consistency in methodology. Haladyna and Shaughnessy summarized the problems that were affiliated with attitudinal research: the research findings on a given area were varied, measurement of attitudes were unreliably measured and consequently relationships are underestimated. They suggest that each report must submit a description of the sample including number of males and females and grade level, reliability estimates and evidence of validity, appropriate analysis procedures, and information on obtaining the use of the instrument. They argue that research should be synthesizable, meaning that if another researcher conducts the same study with the same guidelines, then the results should be similar. Haladyna and Shaughnessey devised a model on attitude which they felt were more useful than the models of Krathwohl et al (1964) and Klopfer (1970, 1976). Based on their model they reviewed the pertinent educational literature and found that research was divided by grade level, gender, socioeconomic status and other variables. Haladyna and Shaughnessey concluded that attitude research was chaotic but that some findings were generalizable. Their research findings indicated that there are small differences in attitudes for boys and girls, gender interacts slightly, some learning environment and teacher variables have been found to be highly related to attitudes and that progress generally has a positive effect on attitudes. Haladyna and Shaughnessey's methods of analysis and Klopfer's classification scheme are examples of the growing concerns of researchers to improve attitude research.

Munby's (1983a) review of the literature on attitude instruments included some 200 instruments that included semantic differential scales, projective instruments, Likert scales and so on. In analyzing attitudes to science Munby (1983a) found only 21 scales out of 56 had been cited in the literature. Munby's analysis showed that many instrument had no reported reliabilities, and validity of the instruments were questionable. The list was further diminished to seven instruments. Munby calls for a reconceptualization of "attitude to science".

Schibeci (1984) reviews the use of meta analysis in attitude research. He argues that researchers interested in using this technique should conduct a reliability trial. That is, two people (or two groups of people) would conduct, quite independently, the meta analysis of the same broad area of concern. The results could then be compared. Another possible method would be to investigate the validity of the method - to what extent are the assumptions which underline the method valid? The results of meta analysis can also be misinterpreted. For example, students in small classes get better test results is too simplistic a conclusion without any consideration of the processes which occur in the classroom.

The efforts of such writers as Munby, Schibeci, Shaughnessy and Gardner have made an impact on the direction of attitude research to science. The recommendations of these educators have been used to direct this study. This is evident in the selection of the attitude instrument used and the type of statistical analysis that is done. The Test of Science-Related Attitude (TOSRA) has had favorable reviews in the educational literature. The TOSRA has also been field tested across various cultures. The question that is the focus of this research is to determine whether or not there is a strong link between attitude and achievement. The evidence so far suggests that the link is weak. Hopefully, this study, taking into consideration the recommendations of Munby and other science educators , will shed further light on the relationship.

CHAPTER 3

EXPERIMENTAL PROCEDURE AND DESIGN

Chapter III consists of three parts. Part I looks at the construction of test items with specific emphasis on the use of the Test of Science-Related Attitudes (TOSRA) by Fraser and the development of exams to measure students achievement.

Part II describes the administration of the tests (instruments) and the collection of data.

Part III presents the analysis and a brief discussion of the relevance of each type of analysis to this study.

Part I. A Rationale for the Construction of Test Items

A. TOSRA questionnaire

Klopfer (1971) devised a classification for science education in which six conceptually different categories of attitudinal aims are distinguished.

Fraser (1978) developed the TOSRA based on Klopfer's classification. The relationships between Klopfer's classification scheme and Fraser's TOSRA is shown below.

Figure 1: A Comparison of Fraser's TOSRA Subscale and Klopfer's Classification Scheme

TOSRA Subscales (1978)	Klopfer's Classification (1971)
1. Social Implication of Science (S)	H•1: Manifestation of favorable attitudes towards science and scientists.
2. Normality of Science (N)	
3. Attitude to Scientific Inquiry (I)	H•2: Acceptance of scientific inquiry as a ray of thought.
4. Adoption of Scientific Attitudes (A)	H•3: Adoption of scientific attitudes.
5. Enjoyment of Science Lessons (E)	H•4: Enjoyment of science learning lessons.
6. Leisure Interest in Science (L)	H•5: Development of interest in science and science related activities.
7. Career Interest in Science (C)	H•6: Development of interest in pursuing a career in science.

The Test of Science-Related Attitudes (TOSRA) was published in 197[illegible] by Fraser. The Manifestation of favorable attitudes towards science and scientists (H•1) has been expanded by Fraser to measure favorable attitudes towards science (S) and as well as Normality of Science (N). The Social Implication of Science (S) subscale consists of statements that look at the social benefits and progress which accompany scientific progress. The Normality of Science subscale measures an appreciation about scientists and their work in a normal context as opposed to being eccentrics in their field. The [illegible]ude to Scientific Inquiry subscale measures attitudes about conducting experimentation in finding out information about the world. The Adoption of Scientific Attitude subscale measures attitudinal aims such as open-mindedness, willingness to revise opinions and so on. The last three subscales: Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science are self explanatory.

The following excerpts are taken from the TOSRA to illustrate the positive and negative statements associated with each subscale. In the Social Implication of Science subscale the statement "Money spent on science is well worth spending" and "Money used on scientific projects is wasted" are examples of positive and negative statements respectively.

The statements "If you met a scientist, he would probably look like anyone else you might meet" as opposed to "Scientists usually like to go to their laboratories when they have a day off" are examples of a positive and a negative statement under the subscale Normality of Scientists.

A positive statement on Attitude to Scientific Inquiry would read "I would prefer to find out why something happens by doing an experiment than by being told" whereas "It is better to be told scientific facts than to find them out from experiments" is an example of a negative statement.

The Adoption of Scientific Attitudes positive and negative statements are as follows: "I enjoy reading about things which disagree with my previous ideas" and "I dislike listening to other people's opinions".

The positive statement "Science lessons are fun" and the negative statement "I would enjoy school more if there were no science lessons" are statements from the Enjoyment of Science Lessons subscale.

The Leisure and Interest in Science subscale have the following positive and negative statements: "I would like to belong to a Science Club" and "I dislike reading newspaper articles about science". Lastly, the statement "I would like to be a scientist when I leave school" is an example of a positive statement, whereas, "I would dislike being a scientist when I leave school" is an example of a negative statement taken from the Career Interest in Science subscale.

Each subscale consists of ten statements. Five of the statements are stated in a positive manner and five statements are stated in a negative manner. Students are asked to express their degree of agreement with each statement on a five point Likert scale consisting of the responses: Strongly Agree (SA), Agree (A), Not Sure (N), Disagree (D), and Strongly Disagree (SD). Scoring involves allocating 5, 4, 3, 2, 1 for the responses, SA, A, N, D, SD, respectively for positive statements. Negative statements are scored 1, 2, 3, 4, 5 for the responses SA, A, N, D, SD. The scores for each subscale can range from a minimum of 10 to a maximum of 50.

Fraser has reported data in the TOSRA seven subscales to include the mean, standard deviation, reliability and scale intercorrelation. A sample of the data is shown on Figure 2.

Figure 2. Fraser's data on the TOSRA (1982)

Scale	Mean	Standard Deviation	Reliability	Test-Retest Reliability
Social Implication of Science	37.3	5.2	0.82	0.76
Attitude of Inquiry	35.9	6.7	0.86	0.79
Career Interest in Science	28.8	8.4	0.91	0.84

The mean scores of each scale range from 28.8 to 37.3 which tend to show that in this sample of students generally have positive attitudes in all areas. The standard deviation indicate the TOSRA generally had a reasonably spread of scores at each level ranging from 5.2 to 8.4. The reliability estimates range from 0.82 to 0.91 indicating that TOSRA has good internal consistency. Test-retest reliability values indicate that the TOSRA is very consistent in achieving similar scores when administered at different time intervals for the same group of students. In compiling the various statistics Fraser recommends that each subscale be treated as a separate entity and not grouped together to achieve an overall score.

The following three subscales were used in the present study: Social Implication of Science (S), Attitude to Scientific Inquiry (I) and Career Interest in Science (C) subscales. The social implication to science subscale was of particular interest since it was felt that adult students would have preconceived notions about science either from past learning experiences in the classroom or from reading and watching the news about science events. The attitude to scientific inquiry was chosen because of the emphasis of lab-oriented activity in the Chemistry and Physics courses offered to the students. The Career Interest in Science subscale was chosen to determine whether or not students that enjoy science would have high TOSRA scores as opposed to students that do not like science or that are not entering a science related technology at NAIT. The shortened TOSRA used in this study included 30 statements. (See Appendix A.)

Statements 1, 7, 13, 19, 25 and 4, 10, 16, 22, 28 were positive and negative statements respectively for the Social Implication of Science subscale.

On the Attitude to Scientific Inquiry subscale the positive statements are 2, 8, 14, 20, 26, and the negative statements are 5, 11, 17, 23, 29.

On the Career Interest in Science subscale items 6, 12, 18, 24, 30 are positive whereas 3, 9, 15, 21, 27 are examples of negative statements.

As shown above, a statement from each of the subscales is presented in a sequential manner so that students respond to the statements without much deliberation to change answers.

An important feature of Likert-type items is that their intention is often obvious to the test respondent and, therefore, it is possible for the respondent to fake responses to reflect opinions which are more positive or negative than they really are. In interpreting student responses to TOSRA, the possibility of faking responses to some items cannot be completely overlooked. Consequently, like most attitude tests, TOSRA is of limited usefulness for the purpose of grading individual students, since students can fake answers to improve their grades. However, as long as TOSRA is not used for grading, there would be little point in students faking responses and reasonable confidence could be placed in student responses. In carrying out this questionnaire it was made clear by the administrators of the subscales that the results were not for grading.

B. Achievement Tests

Students achievement consisted of midterm and final exams marks for English, Mathematics, Physics, and Chemistry.

The student achievement in the Chemistry course was based on the following marking scheme:

1. 10% of the course mark was based on assignments and quizzes.
2. 30% of the course mark was based on two midterms.
3. 30% of the course mark was based on the final exam.
4. 30% of the course mark on laboratory experiments and writing lab reports.

The Chemistry Midterm Exams were prepared by the six instructors that taught the Chemistry course. Each instructor had some input in the preparation of the exams and in the evaluation of the exams. A marking scheme was developed so that all of the instructors would follow the same guidelines.

The format of the first Chemistry Midterm exam consisted of twenty five true and false questions; ten matching statements, twenty six multiple choice questions and a problem solving unit. The format of the second Chemistry Midterm consisted of a true and false, matching, multiple choice and a math section. The number of questions per section varied somewhat from the first midterm depending on the content and the suitability of the questions for that particular section. The final Chemistry exam consisted of the same format and included all of the course material that was taught in the course. The evaluation of the lab consisted of the students completing eleven experiments and writing eleven lab reports. A common marking scheme was used by the instructors.

Part III. Data Collection

a) Sample

The sample of students was taken from the Pretechnology Program during semester one of the academic school year. Students must be at least eighteen years of age to be admitted in the program. The students are usually deficient in English, Mathematics, Chemistry and/or Physics. After one year of upgrading, students are eligible to apply to a technology of interest.

The sample of students in 1988 was approximately 320. The students are randomly placed into groups or sections of which there were eight in number.

Five of the eight groups were randomly selected to participate in the study. The number of students ranged from 35 to 40 per group but by the end of the semester, the average number of students per classroom was approximately 24. This attrition was due to poor academic skills and to lack of financial support to complete schooling.

b) **Procedure**

During week 1 of the semester, the students were notified as to the nature of the study. During week 2, the three subscales of the TOSRA was administered to the five classes to determine student attitudes to science. The Social Implication of Science, the Attitude to Scientific Inquiry and the Career Interest in Science subscales were chosen from the TOSRA. This questionnaire included student's gender, technology of interest, last grade attended in school and age. (See Appendix A.)

During week 8, the first Chemistry Midterm Exam was given to the students. The exam was prepared with the help of the instructors who taught the course. A marking scheme was issued to all of the instructors so that there would be consistency in grading the exams. (See Appendix B.) During week 10, the TOSRA questionnaire with the three subscales was again administered to the students. Administering the TOSRA twice with a time interval between administrations provided a way of determining reliability values. The data could then be compared with those published by Fraser (1981).

During week 12, a third questionnaire was given to the students. This questionnaire included factors that might influence students' achievement. (See Appendix C.)

During week 14, the Second Chemistry Midterm exam was administered to the students. (See Appendix D.)

During week 16, students wrote a comprehensive final exam in Chemistry. (See Appendix E.) Student final grade were determined from midterm I and midterm II scores, final exam and final laboratory mark.

To minimize any discrepancies in evaluation, instructors met on a weekly basis to discuss the level of cognition of the questions based on Blooms taxonomy and to ensure that the objectives of the theory and lab portions of the course were being followed. These steps were taken so that a fair comparison could be made across groups of students as well as having a common criteria to follow in measuring student achievement.

Student midterm and final marks from Physics, English and Mathematics were also collected. This was done to determine any correlations between English, Mathematics, Chemistry and Physics.

In summary, the collection of data included the students' age, grade level, gender, TOSRA 1 and TOSRA 2 scores, and achievement scores in Chemistry, Physics, English and Mathematics. The methods of analyses performed are discussed in the next section.

Part IV. Data analysis

a) **Demographic Data**

Data was collected on gender, last grade attended, age, and whether or not students were applying to a science technology. The objective was to determine if students that were science oriented would score higher on the TOSRA scale as opposed to students that were attending non-science programs at NAIT as well as to include a description of the type of students in Pretechnology.

b) **Mean and Standard Deviation**

The mean is simply the average score taken from a sample. The standard deviation is used to measure the variability of the item scores from the mean. The mean and standard deviation were calculated for all of the data that was collected. This is a standard procedure since all other statistical methods are dependent on knowing the mean and standard deviation, i.e. t-test and analysis of variance (Anova).

The mean and standard deviation were calculated for the TOSRA 1, TOSRA 2 and achievement scores in the various subjects for each class as well as for the total sample.

c) **t-test**

The main use of the t statistic is to compute the variability of the population. The t-test is based on the premise that the sample has been randomly selected and is representative of the population. Another assumption of the t-test is that the distribution of scores is normal. The hypothesis when using the t-statistic is that the sample mean is a true reflection of the population mean. Since the population mean is unknown, it is assumed that there are no differences between the sample mean and the population mean. The Null hypothesis (H_o) would state that the mean should remain the same for both groups after a treatment.

When the t-value is close to zero, the null hypothesis holds true; showing no treatment effect. If the value for t is a large positive or large negative value, then the null hypothesis is rejected suggesting incidence of a treatment effect.

The t-statistic can also be used to assess the effect of a treatment on two samples. This type of study is referred to as an independent measure or between group experimental design. The statistical manipulation is very similar to the simple sample formula except there are two sample means, two population means, and two sources of error. The two samples are pooled or averaged to produce the pooled variance estimate.

The standard error specifies how closely a sample mean estimates to population mean or how much error or variability that is inherent in the experiment. The following example illustrates the theory discussed so far.

Students were categorized into two groups based on whether or not they were applying to a science or non-science technology at NAIT. The students Social Implication of Science scores were also calculated. A t-test was used to determine the differences in the mean scores of the two groups. The results are shown on Figure 3.

Figure 3. Social Implication of Science scores of science and industrial students.

	# of students	Mean	Standard Deviation	Standard Error	t-value	Pooled Variance Estimate	2-tail Probability
Science related	56	39.07	4.68	.56		*df	
Non-Science related	43	39.89	4.76	.73	-0.9	97	0.369

*df = means degrees of freedom

Figure 3 lists the separate means, standard deviation and standard error for both samples which are 39.07, 4.68 and 0.56 for science related and 39.89, 4.76 and 0.73 for the ono-science related students. This shows no differences between the mean scores of the two groups. At a df of 97 and an α of 0.05, the theoretical t-value is $\pm$ 1.96. Any value that falls within this region is an indication that the null hypothesis is true meaning that there are no differences between the mean scores of the two groups. The reported t-value is -0.90 and falls within the accepted region (or 95%) range on the graph indicating no difference between the mean scores of science versus non-science students on the Social Implication of Science subscale, thus accepting the null hypothesis. The two tail probability is 0.369 at an α level of 0.05. The value of 0.369 falls within a region that would accept the null hypothesis meaning that there is no difference between the two groups of students in terms of their TOSRA scores.

d) **ANOVA**

An alternate method to the t-test is the ANOVA. The t-statistic uses t-values whereas the ANOVA uses F-values. The relationship of the two variables is $F=t^2$. Some of the tests that are incorporated into the ANOVA include: the homogenity of variance test and the Scheffé test.

The homogenity of variance test is based on the premise that if the two population variances are the same then, the two sample variances should be similar. Alternately the variance due to experimental error within each of the treatment populations should be homogenous. As a general rule, if the sample variance is four times the variance of the other, then the homogeniety of variance is violated. The Cochrans C-test and the Barlett t-test measure the homogeniety of variance.

The Scheffé's test is used to express the multiple ranges of the sample means when there are more than two treatment groups present. It includes all possible combinations but only compares two groups at a time. The Scheffé test uses an F-ratio for this type of comparison.

An example illustrating the uses of the aforementioned variables is shown below. The analysis of variance test was used to compare differences in grade level, TOSRA 1 and TOSRA 2 scores of students.

Figure 4. Differences in Student Attitudes to Science Scores on the Basis of Grade Level

Grade	Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Scheffè Cochrans	Scheffè Actual	Scheffè Reference
11	9	37.56	7.89	2.63	22	47	.411	4.3	4.83
12	76	36.54	6.88	0.79	10	50			

The above table represents the student scores on attitude to Scientific Inquiry at various grade levels. The Scheffé test based on calculations reports a value of 4.03 when compared to the theoretical value of 4.83. At an α level of 0.05 there are no differences in the means of student attitudes to Scientific Inquiry and grade level.

e) **Correlation**

Correlation measures the degree that two variables may be related. The sample correlation coefficient (r) has the following range of $-1 \leq r \leq 1$. A value of -1 indicates a perfect negative correlation whereas a value of +1 indicates a perfect positive correlation. As r approximates zero, there is less association between two variables. A significant linear relationship between two variables does not necessarily imply a casual relationship.

Correlation were determined between students English Mathematics, Chemistry and Physics achievement scores and students chemistry achievement scores with TOSRA 1 and TOSRA 2.

The various statistical methods that were previously described were used to analyze the data necessary to study the six objectives that are described in Chapter 1. An analysis of the data and its implication will be discussed in Chapter 4. The analysis was done at the University Computing Systems of the University of Alberta using an MTS system PR180 and an SPSS-x Release Statistical Program.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results of the present study are presented and discussed in three sections. The first section gives a description of the demographic data including sample size, students age, gender, and grade level,attitude to science, and achievement scores. The second section reports student TOSRA 1 and TOSRA 2 scores and the test-retest reliability of the TOSRA questionnaire. The student TOSRA scores are also correlated with gender, grade level, liking Chemistry and technology of interest to determine if there are any relationships between these variables. In the third section, student achievement scores are reported for Chemistry, Physics, English and Mathematics. Students' achievement in Chemistry is correlated with gender, TOSRA scores, English, Mathematics and Physics. The relationship between achievement and attitude to science is examined.

Section 1 Demographic Data

The number of students that participated in this study was divided by class, gender, age, grade level and technology of interest. Student attitude to science and achievement scores for the full groups are also presented.

a) Group size

The theoretical number of students that started the study was 157 but only 101 were used in TOSRA 1, 117 for TOSRA 2 and 117 finished the Chemistry course. This disparity was due to attrition and to students not completing the questionnaire in a proper manner. The number of students per group ranged from 14 to 26 for TOSRA 1; 19 to 27 for TOSRA 2 and 19 to 27 for completing the Chemistry course.

Table I A Comparison of the Theoretical and Actual Number of Student Groups that Participated in the Study

		Theoretical	Actual		
Section	Group	Class Size	TOSRA 1	TOSRA 2	Chemistry
1	1	33	22	26	26
3	2	35	26	27	27
5	3	31	23	25	25
7	4	30	16	20	20
8	5	28	14	19	19
Total # of students		157	101	117	117

b) Gender, grade level and technology of interest.

Table II shows the distribution of Pretechnology students according to gender, grade level computed in to attending NAIT and their career interests in the technology of their choice.

Table II Students Divided by Gender, Grade Level and Technology of Interest

	Gender		Grade Level Completed				Science Technology	Industrial Technology
	Male	Female	9	10	11	12		
# of students	73	24	3	7	9	76	56	43

The above table shows that males outnumbered females by a factor of threefold. The majority of students in the Pretech program have had some grade 12 education. Data was not collected to include those students that may have had a Grade 12 Diploma or those students that were deficient in any subject area. Students showed equal preference for science and industrial technologies.

This data was collected during week 2 of the first semester and the distinction between science technology and industrial technology might have been confusing or unknown to the students. Students graduating to the second semester are urged to decide on their choice of four possible divisions. Divisions 1 through 4 are grouped according to technologies that are similar. For example, Division 1 would include all of the various technologies that include the engineering sciences. Students are notified of these 4 major divisions during week six through ten. Students are urged to prepare a career investigation so that they can make an appropriate choice. Collecting this data during week 12 may have reported different values than those reported in Table II, however this is based on speculation.

c) Age

Students were grouped according to six age categories. A percent distribution of each category and the student average age was calculated. The results are shown on Table III.

Table III. Students Classified by Age

Ages	18-20	21-25	26-30	31-35	36-40	41-49	$\bar{x}$
# of students	35	53	19	13	9	5	24
% of total	26	40	14	10	7	4	

The students' ages ranged from 18 to 49 with a reported mean of 24. The majority of students (approximately 66%) ages ranged from 18 to 25.

(d) Students Attitude to Science

Students that participated in this study were divided into 5 groups or classes. The mean and standard deviation were analyzed and the results are presented on Table IV. This data is used to compare the variability of the mean scores of each group and to compare the differences in scores for TOSRA 1 and TOSRA 2.

The Social Implication of Science subscale for TOSRA 1 shows a range of means from 38.14 to 41.27 with an overall mean of 39.49 for the total group. On TOSRA 2 the means ranged from 35.60 to 40.96 with a mean of 37.61 for the total sample. The TOSRA 2 scores show more variability between the groups with a lower sample mean. Group 3 scores

Table IV Comparing Student TOSRA Scores Based on Group Data

Group	T_1 Soc	T_2 Soc	T_1 Att	T_2 Att	T_1 Int	T_2 Int
	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$
1	9.32	35.89	38.23	34.69	32.91	32.23
3	41.27	40.96	38.89	41.60	33.92	34.93
5	38.39	36.16	38.00	34.52	31.83	30.16
7	39.56	35.6	38.94	36.35	33.63	29.45
8	38.14	38.79	34.36	37.00	32.00	30.38
total	39.49	37.61	38.19	36.78	32.91	31.70

were higher than the other groups on TOSRA 1 and TOSRA 2.

The Attitude to Scientific Inquiry subscale for TOSRA 1 shows a range of scores of 34.36 to 34.89 with an overall mean of 38.19. On TOSRA 2 the scores range from 34.52 to 41.60 with an overall mean of 36.78. Again the overall mean is lower for TOSRA 2. Group 5 shows a decrease in their TOSRA scores while groups 5 and 8 show an increase. Group 3 shows the highest score for TOSRA 1 and TOSRA 2.

The Career Interest in Science subscale reports a range of 32.00 to 33.63 and an overall mean of 32.91 for TOSRA 1. Likewise, TOSRA 2 reports a range of 29.45 to 34.93 with an overall mean of 31.70. The overall scores are much closer when compared to the two previous subscales. Group 3 consistently scores higher on all three subscales. However, the differences between the groups is less significant than the difference between the 3 subscales. T_1 SOC, T_1 ATT, and T_1 INT reported means of 39.49, 38.19 and

32.91 as compared to scores of 37.61, 36.78 and 31.70 for T_2 SOC, T_2 ATT, and T_2 INT respectively. The Social Implication of Science subscale reported the highest value for T_1 and T_2 while on the Career Interest in Science it is the lowest for both trials.

The three subscales are similar for TOSRA 1 and TOSRA 2 indicating that there are no major differences within or between groups.

Fraser (1981) using a sample of 342 grade 10 students in Australia reported means of 37.3, 35.9, and 28.8 for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science respectively.

Fraser's data is very similar to the data reported in this research. This does not mean that students in Pretechnology have the same attitudes to science as compared to Australian students but it shows that the TOSRA as an instrument can be used across cultures to give similar results.

(e) Achievement of Students Based on Group Data

(1) Chemistry Marks

Student marks were collected to include 2 midterm exams, final exam, lab assignment and quizzes and final Chemistry mark. The data for lab reports and quizzes were collected, but were not included as data in order to simplify the results. The results of the five groups of student marks are shown in Table V.

Table V Achievement in Chemistry by Groups

Group	Midterm 1 $\bar{x}$	Midterm 2 $\bar{x}$	Chemistry Final Exam $\bar{x}$	Final Mark
1	74.9	56.4	68.3	65.9
3	76.9	62.5	74.6	74.3
5	70.8	59.0	73.7	69.2
7	76.5	62.7	68.0	68.6
8	70.8	60.1	67.3	69.5
mean	74.1	60.1	70.6	70.0

The 5 groups resulted with mean scores that range from 70.8% to 76.9% and an overall mean of 74.1% with a standard deviation of 3 for Midterm 1. The overall mean on Exam 2 is 60.1% which is significantly lower than the previous exam with a range of scores of 56.4% to 62.5%. The reason for this drastic decline in mark may be due to the difficulty of the exam. Since it was shown that student attitude to science does not show a high correlation with achievement, it maybe that other factors such as length of the exam and difficulty in understanding of Chemistry concepts may have contributed to this score. The final means of 65.9%, 74.3%, 69.2%, 68.6% and 69.5% with an overall mean of 70% shows the consistency in the distribution of marks by the various groups.

(2) Student Marks in Other Courses

Student achievement was also collected for Physics, Math 101, Math 102 and English. Students' final marks obtained in these courses are shown on Table VI.

are 28 on TOSRA 1, 19 on TOSRA 2;50 for TOSRA 1 and TOSRA 2 respectively. The Attitude to Scientific Inquiry shows a mean of 38.19 and 36.78 and a standard deviation of 5.32 and 6.37 for TOSRA 1 and TOSRA 2. On Career Interest in Science the means are slightly lower than the means on the other two subscales. The values for the mean are 32.91 and 31.70 and a standard deviation of 6.21 and 6.65. Closer inspection of the mean values of the three subscales indicate slight differences between TOSRA 1 and TOSRA 2. Similar trends are reported for standard deviation and the minimum and maximum values of TOSRA 1 and 2. Generally, there is no statistical difference between the mean scores of TOSRA 1 (pretest) and TOSRA 2 (post test).

b) Test-Retest Reliability of the TOSRA

To determine the test-retest reliability between TOSRA 1 and TOSRA 2 scores a Pearson - Product Moment Correlation was calculated. Fraser (1981) reports the test-retest reliability values of 0.76, 0.79 and 0.84 for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science subscales, respectively. The sample size reported in his study was 324.

In the present study, the test-retest reliability values for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science were 0.44, 0.24 and 0.50 respectively. These values are much lower than the values reported by Fraser. One of the reasons for this disparity is the difference in the sample size of the studies. Another reason is the difference in variability (standard deviation).

Differences in the correlation coefficients reported for the three subscales, imply other factors could be contributing to students TOSRA scores.

c) Coefficient α for TOSRA

The coefficient α reliability estimates are reported for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science for TOSRA 1 and TOSRA 2. These values are compared with the values published by Frazer and are shown on Table VIII.

Table VIII Coefficient α for TOSRA

	TOSRA 1	TOSRA 2	Fraser
Social Implication of Science	0.74	0.82	0.82
Attitude to Scientific Inquiry	0.80	0.87	0.86
Career Interest in Science	0.86	0.87	0.91
Sample Size	101	119	324

Fraser (1981) reports coefficients-α reliability estimates for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science scores as 0.82, 0.86 and 0.91 respectively. These values are large enough to indicate that each TOSRA scale has good internal consistency reliability.

The reported values for the coefficient α on the Social Implication of

Science scale is 0.74 and 0.82; the Attitude to Scientific Inquiry is 0.80 and 0.87 and the Career Interest in Science is 0.87 and 0.87 for TOSRA 1 and TOSRA 2 respectively. These values compares favourably with the values reported by Fraser.

Finally it also implies that the test-retest reliability correlation coefficient reported in this study suggests other contributing factors that would influence student attitude's to science scores. These factors include gender, grade level, enjoyment of science and technology of interest are discussed in sections d, e, f and g.

d) The influence of gender and student attitudes to science.

Table IX attempts to determine whether there are gender differences in student attitude's to science. The mean, standard deviation, t values, degrees of freedom and 2-tail probability values are reported.

Table IX t-Test Showing Gender Differences for TOSRA 1 and TOSRA 2

				Pooled variance estimate		
Variable	Number	Mean	Standard Deviation	t value	df	2 tail probability
T_1 SOC	♂ 73 ♀ 24	39.29 39.88	3.98 5.67	-0.56	95	0.58
T_1 ATT	♂ 73 ♀ 24	37.58 39.67	5.26 5.14	-1.7	95	0.93
T_1 INT	♂ 73 ♀ 24	33.01 32.17	6.23 6.54	0.37	95	0.57
T_2 SOC	♂ 73 ♀ 24	37.68 38.04	5.16 7.83	-0.26	95	0.80
T_2 ATT	♂ 73 ♀ 24	37.04 36.17	6.04 8.36	0.56	95	0.58
T_2 INT	♂ 73 ♀ 24	32.03 30.58	6.83 7.28	0.88	95	0.38

* df = degrees of freedom
♂ = males ♀ = females

On the Social Implication of Science the mean scores for males and femalesare 39.29 and 39.88 respectively for T_1; 37.68 and 38.04 for T_2. These values show that the mean scores are similar between males and females for TOSRA 1 and TOSRA 2. The pooled variance estimate reports a t-value, degrees of freedom and 2 tail probability scores of -0.56, 95 and 0.58 respectively for T_1 SOC and -0.26, 95 and 0.80 for T_2 SOC, respectively. The pooled variance values for T_1 SOC indicate that at an α level of 0.05, there is no significant difference between the mean scores of males and females. A similar profile is shown for T_2 SOC. The variability of student scores are reflected in the t-values of T_1 SOC and T_2 SOC. However both values fall within the 95% confidence interval of the mean indicating no overall differences in the mean scores of males and females.

Alternately on the Career Interest in Science subscale the mean scores on T_1 INT were 33.01 and 32.17 for males and females and 32.03 and 30.58 respectively for T_2 INT. Again the mean scores are very similar within and between groups. The t values are 0.37 and 0.88 for T_1 and T_2 respectively. These values although different give the same results meaning that there are no differences between the mean scores of males and females.

Similar trends are reported for the Attitude to Scientific Inquiry subscale. In summary, there is no difference in student attitudes to science based on gender differences.

e) The influence of grade completed and Student Attitudes to Science

Students were grouped according to last grade completed in school. This included 4 groups of students with a grade 9, 10, 11 or 12 education. Students TOSRA 1 and TOSRA 2 scores were used to determine the influence of grade level and attitude to science. Analysis of variance was used to study this relationship. The results of TOSRA 1 and TOSRA 2 shows similar findings. As a result, TOSRA 1 results will be used to look at the above relationship.

Table X The Influence of Grade Level and Attitude to Science

		T_1 SOC		T_1 ATT		T_1 INT	
Group	n	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Grade 12	76	39.04	4.43	38.11	6.41	33.11	6.41
TOTAL	95	39.44	4.47	38.45	5.18	32.85	6.30

The number of students with a grade 9 and grade 10 education were too low so this part of the data is omitted. Comparing the grade 11 and grade 12 groups show a count of 9 and 76 respectively. The mean for TOSRA 1 are 40.33, 40.11 and 28.11 for T_1 SOC, T_1 ATT and T_1 INT respectively for the grade 11 group. The grade 12 group shows a mean of 39.04, 38.11 and 33.11 for T_1 SOC, T_1 ATT and T_1 INT respectively. There is a slight decrease across the mean scores of TOSRA 1 for both groups and similar means reported between the groups. The analysis indicates that there are no differences between the mean scores of the various groups. Fraser (1981) reported the mean and standard deviation values of 37.3 $\pm$

5.2, 35.9 ± 6.7, 28.8 ± 8.4 for 324 grade 10 students in Australia on the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science. These values when compared to the grade 12 groups also show similar findings suggesting that the TOSRA can be used across cultures to give relatively similar results.

f) The influence of Science Interest and Attitude to Science

Students were asked whether or not they liked Chemistry as a science course. Groups 1 consisted of students that answered yes, group 2 consisted of students that were neutral and group 3 consisted of students that did not like Chemistry. The TOSRA 1 and TOSRA 2 scores of the three groups were compared using analysis of variance to determine if students that liked Chemistry would actually score higher on the TOSRA as opposed to those students that did not like Chemistry.

TOSRA 2 results will be used to discuss the relationship between student attitudes to science and liking Chemistry because it may be a better indicator of assessing student opinions during week 12 of the semester instead of week 2 which is the time that the TOSRA 1 was conducted. Furthermore, analysis of the data between TOSRA 1 and TOSRA 2 and liking Chemistry shows similar findings. Table XI illustrates the relationship of the Career Interest in Science subscale and liking Chemistry. Analysis of Social Implication of Science and Attitude to Scientific Inquiry scale scores provided similar findings and are not presented.

Table XI Analysis of Variance Between Career Interest in Science and Liking Chemistry

Analysis of Variance							
Source		DF	Sum of Square		Mean Squares	F Ratio	F Probability
Between Groups		2	287.51		143.75	3.29	0.41
Within Groups		104	4546.08		43.71		
Total		106	4833.59				
Group	Response	Count	Mean	Standard Deviation	Minimum	Maximum	*95 PCT Conf INT for mean
1	(yes)	69	32.78	7.03	15	50	31.09 to 34.47
2	(Neutral)	15	28.13	6.55	19	46	24.51 to 31.76
3	No)	23	30.87	5.15	22	39	28.64 to 33.09
TOTAL		107	31.72	6.75	15	50	30.43 to 33.01

*95 Percent Confidence Interval for the mean

The sum of squares and mean squares between groups reported values are 287.51 and 143.75 respectively. The F-ratio is 3.29 and F-probability is 0.41 indicating no differences between the mean scores of the three groups.

The mean, standard deviation and 95 percent confidence interval for the students that like Chemistry are 32.78 $\pm$ 7.03, and 31.09 to 34.47 as compared to the values of 30.87 $\pm$ 5.15 and 28.64 to 33.09 for those students that dislike Chemistry. The results indicate fairly similar scores for both groups thus showing no significant differences on the Career Interest to Science subscale. Reported F ratio and F probability values for the Social Implication of Science subscale were 1.58 and 0.21 and 1.98, 0.14 on the

Attitude to Scientific Inquiry subscale. These values indicate no significant differences between those students liking Chemistry as compared to students disliking Chemistry and their TOSRA scores.

g) The influence of a Choice of Technology and Attitude to Science

Students were divided into 2 groups: students that wanted to attend a science related technology and students that wanted to attend an industrial technology. A t-test was done on TOSRA 1 and TOSRA 2 to look at the effects of choice of technology and student attitudes to science. The results appears on Table XII.

Table XII t-Test on TOSRA Scores for Science related and Industrial Related Students

Variable	Number of Cases	Mean	Standard Deviation	t value	2-tail prob.
T_1 SOC	Social Implications of Science				
GROUP 1	56	39.07	4.2	-0.90	0.369
GROUP 2	43	39.88	4.8		
T_1 ATT	Attitude to Scientific Inquiry				
GROUP 1	56	37.77	5.1	-1.02	0.312
GROUP 2	43	38.86	5.6		
T_1 INT	Career Interest in Science				
GROUP 1	56	31.20	4.9	-3.11	0.002
GROUP 2	43	34.95	7.1		
T_2 SOC	Social Implications of Science				
GROUP 1	56	38.13	5.8	0.57	0.568
GROUP 2	43	37.44	5.9		
T_2 ATT	Attitude to Scientific Inquiry				
GROUP 1	56	37.89	5.3	1.47	0.0146
GROUP 2	43	35.91	8.1		
T_2 INT	Career Interest in Science				
GROUP 1	56	30.80	5.9	-1.60	0.113
GROUP 2	43	33.05	8.1		

GROUP 1: Science related technology
GROUP 2: Industrial related technology

The Social Implication of Science subscale reports means of 39.07 $\pm$ 4.2 and 38.13 $\pm$ 5.8 on T_1 and T_2 for those students entering a science technology as compared to means of 39.88 $\pm$ 4.8 and 37.44 $\pm$ 5.9 on T_1 and T_2 for those students that are going to a non-science (or industrial related technology). The reported t value and 2-tail probability values are -0.90 and 0.369 for T_1, 0.57 and 0.568 for T_2 confirming that there are no correlations between students choice of technology and Social Implication of Science.

On the Attitude to Scientific Inquiry subscale TOSRA 1 reports an t value and a 2-tail probability of -1.02 and 0.312 respectively, indicating no differences between the two groups. The means and standard deviations are 37.77 $\pm$ 5.1 and 38.86 $\pm$ 5.6. TOSRA 2 scores provided an t value of 1.47 and a 2-tail probability score of 0.146 indicating that there is a no difference between attitude to Scientific Inquiry and choice of technology. Science related technology (group 1) students provided a mean and standard deviation of 37.89 $\pm$ 5.3. Industrial related technology (group 2) students provided a mean and standard deviation of 35.91 $\pm$ 8.1.

On the Career Interest in Science subscale, the resulted t-value and 2-tail probability scores were-3.11 and 0.002 for TOSRA 1; -1.60 and 0.113 for TOSRA 2. The mean and standard deviation on the Career Interest in Science subscale for TOSRA 1 were 31.20 + 4.9, and 34.95 + 7.1 respectively for group 1 and group 2. On TOSRA 2, the mean and standard deviation were 30.90 + 5.9 and 33.05 + 8.1.TOSRA 1 and TOSRA 2 show that students entering science related technologies (group 1) have lower scores than non science students(group 2). One would expect the reverse to be true in that students that are science oriented would have higher scores than non-science students.

In summary, there seems to be mixed findings between students choice of technology and their TOSRA scores. It may be that students did not comprehend the distinction between science and industrial technologies on the questionnaire or that students opinions on science and attitudes to science have no bearing on their choice of technology.

A better method of data collection would have been to have had 2 categories labelled science and industrial and list the technologies under each heading. Students could then identify their choice and this data could be transcribed and compared with TOSRA 1 and TOSRA 2 scores. It is logical to believe that students who are science oriented would score higher than students who are not science oriented or it may be that there are other factors that are more important in students making decisions on a choice of career. Length of programs, availability of funds and job prospects upon graduation are some factors that may influence a student's decision.

Thus far, section 2 has looked at the Attitudes to Science of students using the three subscales and the heuristic ability of the TOSRA questionnaire as a valid instrument in measuring student attitudes to science. Factors of gender, grade level, liking Chemistry and choice of technology were discussed in reference to the degree of relationship with Attitude to Science. This included an analysis of the entire sample of students.

Section III Student Achievement

This part of the data attempts to investigate the relationship of such factors as English, Mathematics, gender and Attitude to Science with Achievement in Chemistry. The relationship between Attitude to Science and Achievement in Physics will also be examined. A comparison of the corresponding correlations between attitude to science with Physics and Chemistry will be done to determine if the trends are consistent across the two disciplines. Student achievement will be discussed in the following order:

a) Student final marks in Chemistry.

b) Student final marks in Physics, Mathematics and English.

c) Correlation of English, Mathematics and Physics with Chemistry.

d) Correlation between gender and achievement in Chemistry.

e) Correlation between the TOSRA and achievement in Chemistry.

f) Group data of students achievement in Chemistry, Physics, Mathematics and English.

Total Sample

a) Achievement in Chemistry

Students midterm marks and final marks for Chemistry, Physics, Mathematics and English were collected and the mean and standard deviation determined. These marks are used as an indicator of student achievement. In Table XIII, a summary of the results of student achievement in Chemistry is presented. Scores are reported as mean percent.

Table XIII Student Achievement in Chemistry During Semester 1

	Midterm 1	Midterm 2	Final Exam	Final Grade
	x ± SD	x ± SD	x ± SD	x ± SD
	74.08 ± 11.72	60.06 ± 17.2	70.62 ± 17.44	69.54 ± 14.01
# of students	116	115	115	117

The overall means of students in Chemistry Midterm 1, Midterm 2, Final exam mark and final Chemistry mark were 74.08%, 60.06%, 70.62%, and 69.59% respectively. Students final grades included the contribution of the 3 exams as well as the marks obtained on lab reports, assignments and quizzes. Generally, students achievement on the three exams are reasonably good with a slight decrease on midterm 2.

b) Achievement in Other Subjects

Student achievement scores in Physics, Mathematics and English were also collected and the means and standard deviation determined. A summary of the results are presented in Table XIV.

Table XIV Achievement Scores in Physics, Math and English

		Midterm	Final
	Total	$\bar{x} \pm SD$	$\bar{x} \pm SD$
English	117	73.23 ± 13.0	67.32 ± 10.2
Math 101	116	85.72 ± 13.3	77.01 ± 15.3
Math 102	116	80.47 ± 13.8	73.89 ± 13.0
Physics	112	75.19 ± 18.4	70.29 ± 16.5

The achievement scores on midterms and final marks were 75.17%, 70.29% for Physics; 85.72%, 77.01% for Math 101; 80.47%, 73.89% for Math 102 and 73.23%, 67.32% for English. The overall mean for semester 1 was determined to be 71.6% which suggested that Pretech students are generally motivated and want to excel in their studies.

c) The Relationship Between Student Achievement in Chemistry and Other Courses

Since Chemistry is a science that requires students to be versatile in both English and Mathematics, correlation analysis was done to see the degree of relationship between those subjects. In section a, reported means for English, Mathematics, Chemistry and Physics indicate fairly good scores in all subject areas. Table XV reports the correlations between students final marks for Physics, mathematics, English, and Chemistry.

Table XV Correlations of Students Final Marks in Various Subjects

	Physics	Math 101	Math 102	English
Chemistry	0.76	0.70	0.70	0.70
Physics	0.76	0.79	0.83	0.50

The correlations between Chemistry, Math 101, Math 102, and English are 0.70, 0.70 and 0.70 respectively. The correlations between Physics, Math 101, Math 102, and English are 0.76, 0.79, 0.83, and 0.50 respectively. The correlations involving Physics were also done to determine if the values would be similar to those of Chemistry. Taking the square of these values gives a value of approximately .49 which converts to 49% of the factors that are common to the performance in English and Mathematics. Of course, assumption of adequate validity and reliability evidence is necessary.

The correlation of Physics, Math and English are very similar when compared to Chemistry indicating that for both science courses the ability to read, comprehend and problem solve are important in students excelling in Chemistry and Physics.

d) The determination of Gender differences and Achievement in Chemistry

Students final marks in Chemistry were compared with gender to see whether or not males scored higher than females on achievement. The results are listed on Table XVI.

Table XVI t-Test of Achievement and Gender

Chemistry Mark			Pooled Variance Estimate		
Sex	# of Students	$\bar{x} \pm$ SD	t-value	Df	2 tail prob.
male	73	70.26 ± 14.23	7.44	95	0.153
female	24	74.71 ± 8.73			

Females outscored males with reported means of 74.71%and 70.26% respectively. The t-value and 2-tail probability values were 7.44 and 0.153 indicating that there is no statistical difference between the mean scores of males and females.

e) The Relationship Between Attitude to Science and Achievement

The literature to date reports inconclusive findings between attitude to science and achievement. Some researchers report positive correlations while others report no correlation between the two. Correlational analysis were done that included the pretest and post test of TOSRA and achievement in Chemistry midterm exams, Chemistry final exam and Chemistry mark in the course. Also students Physics marks are used to look at relationships between Attitude to Science and Achievement.

Students Chemistry exams were conducted during week 8 and week 14 and the final exam was written during week 16 of the semester. TOSRA 1 was written during week 2 while TOSRA 2 was written during week 10 of the semester. The results are listed on Table XVII using Pearson-Product Moment correlation.

Table XVII Pearson-Product Moment Correlation of Student Attitudes to Science and Achievement in Chemistry and Physics

	Chemistry				Physics
	Midterm 1	Midterm 2	Final Exam	Final Mark	Final Mark
T_1 SOC	0.21	0.13	0.081	0.20	0.1[illegible]
T_1 ATT	0.16	0.16	0.14	0.12	0.[illegible]
T_1 INT	-0.056	0.091	0.081	0.065	0.049
T_2 SOC	0.14	0.11	0.12	0.22	0.055
T_2 ATT	-0.037	-0.0063	-0.029	-0.031	-0.075
T_2 INT	0.048	0.16	0.091	0.15	0.092

On the Social Implication of Science subscale correlation values are 0.21, 0.13, 0.081 and 0.20 for Chemistry Midterm 1, Chemistry Midterm 2, Chemistry Final Exam and Chemistry Final Mark respectively. These values show a weak correlation between the Social Implication of Science subscale and achievement in Chemistry. The reported correlation values of T_2 SOC are 0.14, 0.11, 0.12 and 0.22 for Chemistry Midterm 1, Chemistry Midterm 2, Final Exam and Final Mark respectively. These results are similar to the T_1 SOC results and suggest a weak correlation: The correlation values are 0.16, 0.16, 0.14 and 0.12 for T_1 ATT and -0.037, -0.0063, -0.029 and -0.031 for T_2 ATT. The values close to zero indicate no relationships between Attitude to Scientific Inquiry and Achievement. The Career Interest in Science subscale also shows a range of values from -0.056 to 0.091 on TOSRA 1 and a range of 0.048 to 0.16 for TOSRA 2. Again, these values indicate a weak link between Attitude to Science and Achievement. In summary, the data suggests that student attitudes to science, although positive, does not seem to be associated with student achievements in Chemistry. The TOSRA 1 and TOSRA 2 data when correlated with student Physics marks show a range of -0.075 to 0.21 also indicating a weak relationship.

In summary, section 1 discussed the demographic data that included gender, grade level, technology of interest, age of the students, group scores on attitude to science and achievement. Males outnumbered females threefold, students were 24 years of age on the average, the majority of students had some grade 12 education and students showed equal preference in applying to a science technology as opposed to an industrial technology.

In section II, student attitude to science using the TOSRA as the instrument of study was discussed. The influence of gender, grade level, and liking Chemistry was investigated. The test-retest and α reliability of the TOSRA were also discussed. There was no statistical difference between gender, grade level, liking Chemistry and student attitudes to science. The test-retest reliability data showed that on Career Interest in Science the correlation report only accounted for 25% of the so called "common factors" that students would exhibit in answering the TOSRA questionnaire. Other influences accounted for 75% of the variance of the scores reported for students. The mean scores on the pretest and post test of the TOSRA were fairly close indicating good test-retest reliability. The α reliability values of

TOSRA are consistent with those reported by Fraser and validates the claim that the TOSRA is an excellent instrument in measuring attitude to science.

In section III, factors influencing achievement were discussed. The data showed that Pretech students had an overall average of 72% in semester 1 in all of their courses. This trend was consistent among groups. Student achievement in Chemistry was determined to be influenced by Math and English and less influenced by student attitudes to science. There were no gender differences in achievement. The attitude-achievement relationship appears to be weak-based on the data that was reported. Science courses such as Physics and Chemistry show a weak correlation with attitude to science.

CHAPTER FIVE

SUMMARY AND RECOMMENDATIONS

The research questions of this study that were described in Chapter One can be summarized into two major categories. The first category of questions looks at measuring student attitudes to science using the TOSRA questionnaire and the influence of gender, grade level, liking Chemistry with attitude to science. The second category looked at student achievement and examined the degree of relationship of attitude to science, gender, English and Math with achievement.

Attitude research over time has been very chaotic and inconsistent. This problem stems from misusage of terms, addition of attitudes to yield a single score, and instruments that were inappropriate in measuring attitudes to science. In reviewing the literature, it was recommended that the Likert scale be used in the evaluation of attitude to science. The TOSRA developed by Fraser was used in this study based on the positive recommendations by education researchers in the field of attitudinal research. The TOSRA reported high α reliability values. The α coefficient or (Cronbach coefficient) values on both the pretest and post test showed average values of 0.78, 0.84 and 0.87 on the Social Implication of Science, the Attitude to Scientific Inquiry and the Career Interest in Science respectively. These values indicate that the ten items of each subscale measure the same attitude and compare favourably to the values of 0.82, 0.86 and 0.91 reported by Fraser on the

Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science subscale.

The TOSRA was administered during week 2 and week 10 to compare the test-retest reliability values as well as to determine whether or not student attitudes to science were consistent throughout the semester or whether cognitive variables such as achievement would alter or change student attitudes to science.

A Pearson-Product Moment correlation type of analysis was done to determine this relationship. The results indicate that on the Social Implication of Science subscale the value was 0.44, on the Attitude to Scientific Inquiry subscale the reported correlation was 0.24 and a correlation of 0.50 was determined for the Career Interest in Science subscale. The values when squared denotes the percent of "common factors" displayed by students on completing the pretest and post test of TOSRA. The values of 19%, 6% and 25% show the commonality of these factors on the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science subscales. The α reliability values reported by Fraser (1981) are 0.76, 0.79 and 0.84 for the Social Implication of Science, Attitude to Scientific Inquiry and Career Interest in Science respectively. This difference in the data may be due to the type of students that participated in the study. Fraser's data shows more consistency in student attitudes. However, there is no reference to the type of curriculum used, whether these students were in an academic or non-academic stream and so on. The demographic data of the adult student's indicate that 80% of these students had some grade 12 education. The assumption could be made then that students would have had some exposure to science courses in Elementary, Junior High and Senior High school and that their attitudes to science scores would be more consistent and should be similar to the results reported by Fraser. The Social Implication subscale reported means of 38.5 and 37.6 for TOSRA 1 and TOSRA 2. The means reported on Attitude to Scientific Inquiry were 38.2 and 36.8 for TOSRA 1 and TOSRA 2 respectively. Finally on the Career Interest in Science the reported means on the pretest and post test were 32.2 and 31.7 respectively. The reported means on all of the three subscales indicate fairly close results which would tend to suggest that student attitudes to science are consistent on both trials. The reported correlation values and mean scores reported show mixed findings. Therefore the author's bias is to interpret the data from a practical and educational point of view instead of looking for statistical significance. This bias is based on the fact that most of the factors that were examined in this study reported no statistical significance. The factors that did report statistical significance showed inconclusive findings when different groups or treatments were compared.

It is debatable whether or not TOSRA 2 should have been administered at the end of the semester in order to examine the test-retest reliability hypothesis. Student attrition was a concern in not administering the

TOSRA questionnaire at the end of the semester.

The determination of attitudes to science of Pretech students show a mean score of 38, a minimum score of 19 and a maximum score of 50 on the Social Implication of Science subscale. A minimum score of 19 indicates those students having a negative attitude to Science as opposed to a score of 50 which signifies those students that have favorable attitudes to science. The score on each subscale was derived in the following manner: a score of 5 was given for positive items and a score of 1 was given for negative statements if the response was strongly agree on the Likert scale. Students that responded in a neutral manner received a score of 3. Therefore, a score of 30 would indicate a student having a neutral attitude on that particular subscale. The average score for TOSRA 1 and TOSRA 2 were 37 and 32 for the Attitude to Scientific Inquiry and Career Interest in Science subscales. This data indicates that Pretech students showed slightly positive attitudes to science. The frequency distribution of TOSRA 1 shows that 10% of the students have scores less than 30, 50% of the students have scores between 31 and 40 and 40% of the students have scores between 41 and 50. On T_2 SOC, [illegible]% of the students had scores of less than 30, 4% of the students had scores of 30, 62% of the students had scores ranging from 31 to 40 and 28% of the students had scores of 41 to 50. The frequency distribution, however, for both TOSRA 1 and TOSRA 2 indicate different sample size and it is uncertain the implications these scores have on determining if in fact there were changes in student attitudes to science.

The frequency distribution does not show the scores of each student and this kind of information would have been important in comparing students with high TOSRA scores versus students with low TOSRA scores and also to determine if this trend was consistent by the end of the semester. However, due to the limited number of students that participated in this study, this type of analysis would be futile because of the small percentage of students exhibiting negative attitudes to science.

The research literature on gender and attitudes to science shows that traditionally males have more positive attitudes in the physical science than females. The data gathered in this study shows that there is no difference in male and female attitudes to science. The reported means on TOSRA 1 and TOSRA 2 are almost identical. However, males outnumbered females by a factor of three fold. Whether or not a larger sample would have showed differences in male and female attitudes is purely based on conjecture.

This research also suggests that students tend to show a decrease in attitude to science with increasing grade level. Again, the sample of students with a grade 9, grade 10 and grade 11 education in Pretechnology were too low to draw any meaningful conclusions.

The relationship between students liking Chemistry as opposed to students not liking Chemistry shows that on the Career Interest in Science subscale, the means of the two groups are almost identical. This trend was consistent in both the Social Implication of Science and Attitude to Scientific Inquiry subscales. Both groups showed favorable attitudes to science on the three subscales.

Attitudes to science scores may not be good indicators of whether or not students would like or dislike a particular science course. Perhaps attitude to science scores simply indicate attitudes that are derived from media and past experience and that student attitudes are rarely changed within the classroom setting and may be, to determine any long lasting changes in student attitudes to science would necessitate a longitudinal type of study. It is also possible that students in answering the TOSRA questionnaire used a "common sense" approach. The fact that after 10 weeks of classes student TOSRA scores were almost identical tend to support this claim. In retrospect, it would have been interesting to determine student TOSRA scores one year later to see whether or not there were changes in student attitudes to science.

The similar findings in TOSRA 1 and TOSRA 2 and the fact that there were no differences in attitude when related to gender, grade level, liking Chemistry and choice of technology may indicate that Pretech students, because of their age and past educational experience are very motivated to succeed in school. Pretech students "need to achieve" necessitates that they pass their courses in semester one so that they can be eligible to be accepted in their choice of technology at NAIT. This may be a measure of their motivation. It is also interesting to note that the literature shows student motivation as a major influence on achievement and to a lesser extent attitude to science. The author acknowledges that perhaps students motivation could have been measured in much the same manner as student attitudes to science to determine whether similar results would have been found.

Achievement was measured using the grades reported in the various courses by the instructors in the first semester. Chapter 3 explained the rationale behind the evaluation and the collecting of student marks.

The overall means reported for Chemistry, Physics, Math 101, Math 102 and English were 69.5%, 70.3%, 77.0%, 73.9% and 67.3% respectively. The results indicate fairly consistent scores in all subject areas and tends to support the assumption that Pretech students are motivated and have the desire to excel in their studies. The analysis of achievement by groups showed that the grades were also fairly consistent.

The need to include other subject areas in the study did not detract from looking at students achievement in Chemistry and attitude to science but also helped to substantiate the data by comparing Physics grades and attitude to science. The relationship of Math, English, gender and attitude to science was really to see the contributions of each factor in determining students achievement.

The correlations of Chemistry with Math 101, Math 102, and English were 0.70, 0.70 and 0.70 respectively. These values correspond to 49% of the common factors that account for student achievement. The correlation of achievement and gender shows that girls score slightly higher in Chemistry. The reported means were 70.3% and 74.7% for boys and girls respectively, however, these results were not seen to be significant at the 95% probability level.

The correlation of attitude to science and achievement varies from as low as 0.07 to as high as 0.84. Simpson (1981) reported that attitude to science accounted for 30% of the variance in achievement. Wilson (1983), determined the correlation between attitude and achievement of 0.17, 0.21, 0.16 and 0.12 at the Elementary, Junior High, Senior High and College level. These values show a very low correlation between attitude and achievement. This study reports correlation values of 0.20 and 0.14 for Chemistry and Physics achievement with the Social Implication of Science subscale on TOSRA 1 and values of 0.22 and 0.055 on TOSRA 2. The correlation of Attitude to Scientific Inquiry with achievement reports values of 0.12 and 0.21 on TOSRA 1; and values of -0.031 and -0.075 on TOSRA 2 for Chemistry and Physics. The correlation scores of 0.065 and 0.049 on TOSRA 1, 0.15 and 0.092 on TOSRA 2 represents the relationship of Chemistry and Physics with Career Interest in Science. Overall, the scores indicate that attitude to science as measured by the three subscales show a weak correlation with achievement. Attitude to science accounts for only 4% of the variance in achievement and this is the highest correlation value that is reported in the study. It would have been interesting to determine whether or not students that like Chemistry actually out performed students that did not like Chemistry on Achievement and to assess this in lieu of their attitude to science. Student opinions on liking or not liking Chemistry may be related to their attitudes and perhaps this is reflected in their achievement. The marks reported for achievement are very high, so the question of whether attitude influenced achievement or achievement influenced attitude is difficult to determine since the correlation between the two variables are extremely low.

Student attitude to science scores were positive and their achievement scores were fairly high so one would expect a high correlation between the two variables, however the results indicate the opposite trend. The consistency showed on students TOSRA 1 and TOSRA 2 scores and the consistency showed on achievement in the various courses should also tend to support a high correlation. It may be that other factors such as age of the students, their motivational level, sense of urgency in wanting a career and so on may be contributing to student achievement scores. This is purely hypothetical and further research may want to include the above factors. In summary, the correlation between attitude and achievement is low and supports the data published by Wilson(1983).

Implication for Classroom Instruction

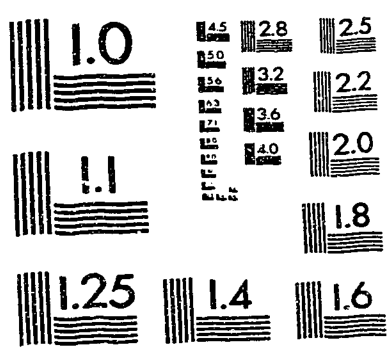
Teachers have tended to ignore the affective domain during instruction because of the concerns of indoctrination of students and the level of subjectivity that is involved in the evaluation of affective objectives. The TOSRA questionnaire can be used as a diagnostic tool in determining student attitudes to science. The present study did not look at individual student TOSRA profiles in determining if indeed there were changes in student attitudes. Students showing weak attitudes to science can hopefully be improved by reinforcing the positive aspects of science. This is important because of the increasing decline of students in the sciences in secondary and post-secondary education. Developing positive attitudes in students hopefully means that they would enjoy and spend more time studying the sciences which would eventually lead to improvement in achievement. This study looked at many factors that influence attitude and achievement. Perhaps the major emphasis has to be the teacher in promoting positive student attitudes to science. Teachers may want to use the TOSRA or other related instruments in assessing student attitudes and then use various teaching methods which may lead to improvement in attitude and achievement.

Recommendations

The data discussed in Chapter IV suggests that since the correlation between attitude and achievement was poor, then perhaps improving the design of the study may have improved the results.

2 of/de 2

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT



1) In the implementation of the TOSRA the author suggests that the administration of this instrument should have been done before the second week of school and be given to the students on the first day of classes or if possible be done upon student requesting admission into the Pretechnology program.

Also, it may be that the second administration of the TOSRA questionnaire could have been done at the end of semester 1 or perhaps the study should have included those students taking Chemistry in the second semester and follow up test-retest reliability be done with these students. Since student attitude to science scores did not differ, in the overall sample, then individual profiles could have been monitored to look at changes in student attitudes to science.

2) The author also acknowledges that the data could have also included specific science courses that were completed by students at the High School level to determine whether or not this was important in shaping student attitudes to science or perhaps attempt to determine students preconceived notions of science.

3) The TOSRA has a high level of reliability and validity. The author questions whether or not a specific scale should have been created for Chemistry. Of course this would have involved field testing of the questions. But in discussing the methodological problems in attitude research, the author opted to use a scale that had been recommended in the educational

literature.

4) The request to include all eight sections of Pretechnology and the seven subscales of TOSRA was denied by administration. The analysis that was done lacked the recommended sample size so the data could not be meaningful.

5) The analysis should have included correlation of age, grade level, liking Chemistry and choice of technology with achievement. However, the principle objective was to look for any attitude-achievement links.

6) The author also recommends that qualitative data could have been collected to investigate student attitudes specific to Chemistry. Qualitative data may add more credibility to the research by looking at the more salient features of attitude and achievement. It may be that this type of research can assess the three components of attitudes mainly the cognitive, affective and behavioral. Interviews could have included students that were high achievers and low achievers and compare their TOSRA scores in lieu of attitude and achievement. It may be that the reported low correlations linking attitude to achievement involves a methodological problem in using statistics to interpret the data. Even if the data is statistically significant, one cannot imply a causal relationship between two variables.

From the above discussion it should be evident that the present study has attempted to look at the attitude achievement link and to assess some of the factors that are related to attitude and achievement. The data confirms the reported values in the literature on attitude and achievement. This study is unique in the sense that it includes adult upgrading students to investigate the influence of attitude and achievement. To date this type of sample is not common in the education literature on attitude achievement research.

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APPENDIX A

The educational literature consists of many studies on achievement. Factors such as age, sex, years of schooling, motivation, attitude to science, and teacher characteristics and so on have been shown to have an influence on students achievement. The following study attempts to look at some of these factors influence on students achievement. The results obtained will be used to help future students in the Pretechnology program.

Part one of the study involves the student providing some personal information and completing a questionnaire on science related attitudes.

Part two of the study consists of a second questionnaire aimed at determining what are some factors that influence achievement. This will be given during the tenth week of the first semester.

The information gathered in this study will be held in confidence and be used only by the person conducting the study. You are not obligated to participate in this study but it is hoped that your assistance will help improve our understanding of adult learners.

Name: ______________________________

Student I.D. number ________________________

Phone: ______________________________

Sex: Male (M) / Female (F)

Year you last attended school ____________

Last grade attended __________________

Date of birth ______/______/________

Career goals: ____

TOSRA

Test of Science Related Attitudes

DIRECTIONS

1. This test contains a number of statements about science. You will be asked what you yourself think about these statements. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

2. All answers should be given on the separate Answer Sheet.

3. For each statement draw a circle around

   SA if you strongly agree with the statement

   S if you agree with the statement

   N if you are not sure

   D if you disagree with the statement

   SD if you strongly disagree with the statement

Practice item

It would be interesting to learn about boats.

Suppose that you agree with this statement then you would circle A on your answer sheet

SA	A	N	D	SD

4. If you change your mind about an answer, erase it out and circle another one.

5. Although some statements in this test are fairly similar to other statements, you are asked to indicate your opinion about all statements.

STATEMENTS

1. Money spent on science is well worth spending.
2. I would prefer to find out why something happens by doing an experiment than by being told.
3. I would dislike being a scientist after I leave school.
4. Science is man's worst enemy.
5. Doing experiments is not as good as finding out information from teachers.
6. When I leave school I would like to work with people who make discoveries in science.
7. Public money spent on science in the last few years has been used wisely.
8. I would prefer to do experiments than to read about them.
9. I would dislike a job in a science laboratory after I leave school.
10. Scientific discoveries are doing more harm than good.
11. I would agree with other people than do an experiment to find out for myself.
12. Working in a science laboratory would be an interesting way to earn a living.
13. The government should spend more money on scientific research.
14. I would prefer to do my own experiments than to find out information from a teacher.
15. A career in science would be dull and boring.
16. Too many laboratories are being built at the expense of the rest of education.

17. I would rather find out about things by asking an expert than by doing an experiment.
18. I would like to teach science when I leave school.
19. Science helps to make life better.
20. I would solve a problem by doing an experiment than be told the answer.
21. A job as a scientist would be boring.
22. This country is spending too much money on science.
23. It is better to ask the teacher the answer than to find it out by doing experiments.
24. A job as a scientist would be interesting.
25. Science can help to make the world a better place in the future.
26. I would prefer to do an experiment on a topic than to read about it in science magazines.
27. I would dislike becoming a scientist because it needs too much education.
28. Money used on scientific projects is wasted.
29. It is better to be told scientific facts than to find them out from experiments.
30. I would like to be a scientist when I leave school.

APPENDIX B

NAME: ____________________

CHS 101

MIDTERM EXAM

October 11, 1988

total marks = 95

Answer the following questions with T for **TRUE** and F for **FALSE**.

_____ 1) A chemist changes the data to fit the hypothesis.

_____ 2) Silicon is in period 3 on the periodic table.

_____ 3) There are 8 elements in the third column of the period table.

_____ 4) C is the symbol for calcium.

_____ 5) There are 4 significant figures in the number 3.400.

_____ 6) $0.00623 = 6.23 \times 10^{3}$.

_____ 7) There are 2 elements in the first period of the periodic table.

_____ 8) 38L = 38,000 mL.

_____ 9) The atomic number for potassium is 15.

_____ 10) Fluorine has more protons than carbon.

_____ 11) Elements in the same period have similar properties.

_____ 12) Cutting glass tubing is a chemical change.

_____ 13) A gas has an indefinite shape, a definite volume and can be compressed significantly.

_____ 14) The symbol for Beryllium is Be.

_____ 15) A carbon atom has 6 protons and 6 electrons.

_____ 16) $2\ m^3 = 2{,}000{,}000\ cm^3$

______ 17) 100 mL = 100 cc.

______ 18) An element is a pure substance.

______ 19) A liquid has weak attractive forces.

______ 20) A hypothesis is a theory which has been well tested.

______ 21) The specific gravity of water at 4°C is 1.00 g/mL.

______ 22) Vinegar is a homogeneous mixture.

______ 23) The electrons are found in the nucleus.

______ 24) A neutron has more mass than an electron.

______ 25) Rusting of iron is a physical change.

/25 marks

Match the letter of the term from the list which best fits each of the following statements.

______ 26) A pure substance.

______ 27) A homogeneous portion of a mixture with a distinct boundary.

______ 28) This amount is dependent on gravity.

______ 29) This particle has no charge.

______ 30) This value decreases as the temperature is raised, and has no units.

______ 31) This substance is uniform throughout.

______ 32) This particle is not found in the nucleus.

______ 33) The amount of matter in a substance.

______ 34) The smallest portion of an element which retains the properties of that element.

______ 35) The relationship between mass and volume.

A) Atom
B) Density
C) Electron
D) Element
E) Energy
F) Heat
G) Heterogeneous
H) Homogeneous
I) Mass
J) Matter
K) Neutron
L) Phase
M) Proton
N) Specific Gravity
O) Temperature
P) Weight

Answer the following multiple choice questions by circling the letter of the correct answer. Circle only one letter per question. Any questions with more than one letter circled will be marked wrong.

36) Oxygen has how many protons?
- a) 16
- b) 6
- c) 8
- d) 15.9994

37) What is the symbol for Calcium?
- a) C
- b) Cu
- c) Ca
- d) Co

38) What is the answer to the following math problem with the proper significant figures?

$$6.81 \times 10^3 - 2.225 \times 10^3 =$$

- a) 4.58×10^3
- b) 4.585×10^3
- c) 4.6×10^3
- d) 4.59×10^3

39) The atomic # for neon is 10 and the mass # is 21. Which of the following is correct?
- a) 10 protons, 11 neutrons and 11 electrons
- b) 11 protons, 10 neutrons and 11 electrons
- c) 10 protons, 21 neutrons and 10 electrons
- d) 10 protons, 11 neutrons and 10 electrons

40) Which of the following properties changes with temperature?
- a) boiling point
- b) atomic number
- c) mass number
- d) density

41) Where will mass = weight?
   a) Only on the moon
   b) Only on earth
   c) Only in outer space
   d) On any balance anywhere

42) Which of the following will always form a heterogeneous mixture?
   a) sand and water
   b) salt and water
   c) sugar and water
   d) water and water

43) An object having the dimensions 20 cm x 15 cm x 3 cm has what volume?
   a) 38 cm
   b) 900 mL
   c) 38 cm^3
   d) 900 cm

44) If an object has a volume of 25 mL and has a mass of 20 grams what is its density?
   a) 1.2
   b) 1.2 g/mL
   c) 0.80
   d) 0.80 g/mL

45) If an oil floats on water, which of the following is most likely its specific gravity?
   a) 1.3
   b) 1.3 g/mL
   c) 0.93
   d) 0.93 g/mL

46) 1.00 cm is equal to how many meters?
   a) 2.54
   b) 100
   c) 10
   d) 0.01

47) The number 0.0048 contains how many significant figures?
   a) 1
   b) 2
   c) 3
   d) 4

48) Express 0.00382 in scientific notation.
   a) 3.82×10^{3}
   b) 3.8×10^{-3}
   c) 3.82×10^{-2}
   d) 3.82×10^{-3}

49) The conversion factor to change grams to milligrams is:
   a) $\frac{100 \text{ mg}}{1 \text{ g}}$
   b) $\frac{1 \text{ g}}{100 \text{ g}}$
   c) $\frac{1 \text{ g}}{1000 \text{ mg}}$
   d) $\frac{1000 \text{ mg}}{1 \text{ g}}$

50) Which of the following is not a physical property?
   a) boiling point
   b) physical state
   c) bleaching action
   d) color

51) Which of the following is a physical change?
   a) A piece of sulfur is burned.
   b) A firecracker explodes.
   c) A rubber band is stretched.
   d) A nail rusts.

52) Which of the following is a chemical change?
   a) Water evaporates.
   b) Ice melts.
   c) Rocks are ground to sand.
   d) A penny tarnishes.

53) Which of the following is a mixture?
   a) water
   b) mercury
   c) sugar solution
   d) air

54) Which is the most compact state of matter?
   a) solid
   b) liquid
   c) gas
   d) solution

55) The changing of liquid water to ic is known as a
   a) chemical change
   b) physical change
   c) homogeneous change
   d) heterogeneous change

56) Which of the following does **not** represent a chemical change?
   a) heating copper in air
   b) combustion of gasoline
   c) cooling of red-hot glass
   d) digestion of food

57) Which of the following is not a pure substance?
   a) lead
   b) wood
   c) potassium
   d) water

58) Which of the following is a mixture?
   a) water
   b) chromium
   c) wood
   d) sulfur

59) Coffee is an example of
- a) an element
- b) a compound
- c) a homogeneous mixture
- d) a heterogeneous mixture

60) The concept of the positive charge and most of the mass concentrated in a small nucleus surrounded by the electrons was the contribution of:
- a) Dalton
- b) Rutherford
- c) Bohr
- d) Schrodinger

61) The concept of electrons existing in specific orbits around the nucleus was the contribution of:
- a) Thomson
- b) Rutherford
- c) Bohr
- d) Schrodinger

62) Give the atomic structure notation (Bohr electron distribution) for silicon.

atomic # = 14
mass # = 28

/3 marks

63) Give the atomic structure notation (Bohr electron distribution) for Calcium.

atomic # = 20
mass # = 39

/3 marks

Answer the following problems, showing your calculations, and using the proper significant figures.

64) Convert 285 cm^3 to L.

/3 marks

65) -28.5°F to K.

/3 marks

66) 3.00 $mile^3$ to mm^3 (1 mile = 1.61 km)

/5 marks

67) A king sized water is 1.90 m long, 1.50 m wide, and 0.255 m deep. Calculate the mass of water in **Kg** that will fill the bed to capacity. Density of water = 1.00 g/mL.

/5 marks

69) Fill in the following:

/12

Symbol	Name
H	____________
Zn	____________
Na	____________
Sn	____________
Cl	____________
Fe	____________
____________	carbon
____________	gold
____________	magnesium
____________	aluminum
____________	mercury
____________	copper

APPENDIX C

Questionnaire #2

This questionnaire is to determine what factors may affect students achievement. The results of this questionnaire and the science related questionnaire will be used to improve our understanding of adult learners. The benefits will also mean that more attention will be taken to upgrade the Pre-tech program.

The ability to excel in math, in reading, in writing, in recalling information, in having good study skills, and in having good time management are examples of factors that have an influence on students achievement. The brilliant students as well as the slower students have varying degrees of these abilities. Looking back at your overall performance in Pre-tech, indicate whether these factors have had a major influence on your performance so far. By this I mean that if this problem was corrected, it would mean an increase of **15% or better** in Chemistry.

Using the score sheet write your name, ID#, date of birth, sex, and grade in the appropriate section using an Hb pencil.

Answer all questions on the scoresheet provided.

For each statement shade in the circle around:

1 or SA if you **strongly agree** with the statement

2 or A if you **agree** with the statement

3 or N if you are not sure **(neutral)**

4 or D if you **disagree** with the statement

5 or SD if you **strongly disagree** with the statement

If you decide to change an answer, simply erase it and circle another one.

Example I enjoy Chemistry.

SA	A	N	D	SD
1	2	3	4	5

I have shaded in #1 on my answer sheet because I strongly agree with the statement.

Time Management

The amount of study time devoted to Chemistry includes the hours spent doing assignments, doing lab reports, and memorizing the Chemistry content.

1. The amount of hours spent studying Chemistry per week are
   a) 1-3
   b) 4-6
   c) 7-9
   d) 10-12
   e) >12

For the next question, please Circle one answer.

2. The course that demands most of your time is
   a) Chemistry
   b) Physics
   c) Algebra
   d) English
   e) Trigonometry

3. Did you attend the seminar on time management? If Yes, circle A and answer the next question. If No, circle B and proceed to question #5.

4. The seminars offered through counselling on time management was sufficient to help you in studying.

SA	A	N	D	SD
1	2	3	4	5

5. Do you have a part-time job? Circle yes or no.
   A) Yes
   B) No

If you answered yes continue on to #6. If you answered no, proceed to #7.

6. Working a part-time job has contributed to your poor performance in Chemistry.

SA	A	N	D	SD
1	2	3	4	5

7. Do you have a wife and/or dependents. Circle Yes or No.
   a) Yes
   b) No

8. My immediate family limits the amount of time I can spend doing Chemistry.

SA	A	N	D	SD
1	2	3	4	5

<u>Test Anxiety</u>

Some students experience enormous stress or anxiety when writing exams which results in poorer performance than expected.

9. You experience high levels of stress during exams despite adequate preparation.

SA	A	N	D	SD
1	2	3	4	5

10. The level of stress hinders your ability to relax and think logically.

SA	A	N	D	SD
1	2	3	4	5

11. As you leave the exam room, you tend to remember the information much faster and have little or no problems in getting the correct answers to the questions.

SA	A	N	D	SD
1	2	3	4	5

12. Your performance could be greatly increased if you can control your anxiety level.

SA	A	N	D	SD
1	2	3	4	5

Math

To perform well in Chemistry means being able to manipulate formulas and solve problems.

13. My mark in Math (ASM 101 - Algebra) is
    a) below 50%
    b) between 50 - 65%
    c) between 66 - 80%
    d) above 80%

14. My mark in Math (ASM 102 - Trigonometry) is
    a) below 50%
    b) between 50 - 65%
    c) between 55 - 80%
    d) above 80%

15. I have no problems in understanding Chemistry, but my math ability limits how well I perform on math related questions.

SA	A	N	D	SD
1	2	3	4	5

16. My math ability has no bearing on my performance in Chemistry.

SA	A	N	D	SD
1	2	3	4	5

English

The ability to read and comprehend is very important in being able to perform well in Chemistry.

17. My mark in English is:
    a) below 50%
    b) between 50 - 65%
    c) between 66 - 80%
    d) above 80%

18. I have difficulty understanding what is asked on the questions and this is a result of my poor performance.

SA	A	N	D	SD
1	2	3	4	5

19. My ability to comprehend English had no bearing on my performance in Chemistry.

SA	A	N	D	SD
1	2	3	4	5

Retention

One criteria of checking whether or not you know the course material is the ability to regurgitate the information back on paper. This requires practice.

20. I have difficulty in memorizing any information.

SA	A	N	D	SD
1	2	3	4	5

21. I have difficulty in memorizing Chemistry.

SA	A	N	D	SD
1	2	3	4	5

22. I do not have difficulty in memorizing the Chemistry content but I am still performing below my capabilities.

SA	A	N	D	SD
1	2	3	4	5

Course Content

The organization of the course material in a logical and coherent manner is important in students performing well in the course.

23. The Chemistry content was too theoretical and therefore difficult to understand.

SA	A	N	D	SD
1	2	3	4	5

24. The Chemistry content required a lot of memorization.

SA	A	N	D	SD
1	2	3	4	5

25. The Chemistry content could be made easier if more films and demonstrations were used.

SA	A	N	D	SD
1	2	3	4	5

26. The Chemistry content was reinforced with the labs.

SA	A	N	D	SD
1	2	3	4	5

27. The Chemistry content was reinforced with the labs.

SA	A	N	D	SD
1	2	3	4	5

28. The Chemistry content was not easy to understand.

SA	A	N	D	SD
1	2	3	4	5

29. Please circle in the appropriate section the years that you have been out of school.
    a) 1-3 years
    b) 4-6 years
    c) 7-10 years
    d) greater than 10 years

30. Do you like Chemistry?
    a) Yes
    b) No
    c) Neutral

31. How would you rate your level of motivation.
    a) very strongly motivated
    b) strongly motivated
    c) motivated
    d) somewhat motivated
    e) not very motivated

APPENDIX D

PRETECHNOLOGY

CHEMISTRY 101 MIDTERM EXAM #2

November 22, 1988

NAME:______________

SCORE:______________
90

Answer the following questions with T for true and F for false.

_____ 1) He is the most electronegative element.

_____ 2) The P - Cl bond would be a polar covalent bond.

_____ 3) He_2 is a diatomic molecule.

_____ 4) Li would be more metallic than Rb.

_____ 5) Calcium is an Alkaline Earth Metal.

_____ 6) Aluminum has a larger radius than sodium.

_____ 7) Metals combine with the halogens to form salts.

_____ 8) CCl_4 is a nonpolar molecule.

_____ 9) Because NaCl is a polar compound it will dissolve in water.

_____ 10) Se would be expected to form a 2- ion.

_____ 11) Br would be expected to form a 7- ion.

_____ 12) NH_4OH is an ionic compound.

_____ 13) Ionic compounds form a lattice crystal.

_____ 14) Na forms mainly covalent bonds.

_____ 15) Ionization energy is the amount of energy required to add an electron to an atom.

_____ 16) The lower the ionization energy, the more metallic the element is.

_____ 17) Two isotopes have the same symbol, but different atomic numbers.

_____ 18) A metal plus a nonmetal would be expected to form an ionic compound.

_____ 19) Two elements having the same number of protons but having different numbers of neutrons would be isotopes.

_____ 20) Iodine would be expected to have a greater electron affinity than fluorine.

_____ 21) It is possible to calculate the molecular mass of $AlCl_3$.

_____ 22) The atomic mass of potassium is 30.975 g/mole.

_____ 23) Chlorine is a halogen.

_____ 24) LiBr does not contain metallic lithium.

/24 marks

Part B

Answer the following multiple choice questions by circling the letter of the correct answer. Circle only one letter per question. Any questions with more than one letter circled will be marked wrong.

1) Which of the following is an ionic compound?
   a) NH_3
   b) CCl_4
   c) PBr_3
   d) NH_4F

2) Which of the following is not a diatomic molecule?
   a) hydrogen
   b) neon
   c) chlorine
   d) nitrogen

3) What is the definition of a molecule?
   a) The smallest unit of a molecular compound which retains the properties of that compound.
   b) The smallest unit of an element which retains the properties of that element.
   c) A cation plus an anion.
   d) A metal plus a nonmetal.

4) How many atoms are in the formula $(NH_4)_2SO_4$?
   a) 11
   b) 13
   c) 10
   d) 15

5) Who is credited with the development of the modern periodic table?
   a) Moseley
   b) Medeleev
   c) Meyer
   d) Dobereiner

6) What is the formula mass of Cu_2SO_4?
   a) 111.61 g/mole
   b) 176.23 g/mole
   c) 223.15 g/mole
   d) 319.34 g/mole

7) Which of the following covalent bonds would be the most polar?
   a) C - O
   b) B - F
   c) F_2
   d) C - N

8) The isotope carbon -14 would have which of the following?
   a) 6 protons and 8 neutrons
   b) 8 protons and 6 neutrons
   c) 6 protons and 14 neutrons
   d) 12 protons and 2 neutrons

9) Which of the following compound formulae is correct?
   a) SrO_2
   b) NaN_3
   c) BeCl
   d) Ca_3P_2

10) A polar compound is . . .
   a) made up of nonpolar bonds.
   b) soluble in nonpolar compounds.
   c) found only in the arctic and the antarctic.
   d) soluble in polar compounds.

11) Ionic compounds are . . .
   a) made from a metal plus a metal.
   b) the least polar compounds.
   c) the most polar compounds.
   d) formed through the sharing of electrons.

12) Why is NaCl soluble in water?
   a) Because water is an ionic compound.
   b) Because water is a polar compound.
   c) Because NaCl is a molecular compound.
   d) Because water is a liquid.

13) Lewis dot electrons are . . .
   a) the only electrons in an atom.
   b) equal to the period # in which the element occurs.
   c) found only in the innermost energy shell.
   d) the same as valence electrons.

14) Which of the following statements is true of the atomic radius?
   a) It is independent of the number of electrons.
   b) It determines whether or not an element will form a cation.
   c) It is largest at the top right of the periodic table.
   d) Helium has the smallest radius.

15) Which family of elements will react with the halogens to form a 1:1 ratio?
   a) alkaline earth metals
   b) metalloids
   c) noble gases
   d) alkali metals

16) Metals
   a) form cations.
   b) are malleable.
   c) are ductile.
   d) all of the above

17) Water is an example of
   a) ionic bonding
   b) coordinate covalent bonding
   c) polar covalent bonding
   d) non-polar covalent bonding

18) Electronegativity
   a) is the ability to repel a pair of electrons
   b) increases for metals and decreases for non-metals
   c) increases as you go from right to left on the periodic table
   d) is the ability to attract a pair of electrons

/18 marks

Part C

1. Fill in the following table:

element electrons	atomic isotopic	mass #	protons #	neutrons	notation
		16	16		

/5 marks

Part D

1. Predict the compound formulae for the following:

a) K and F

b) Be and P

c) Li and CO_3^{2-}

d) Ca and OH^-

e) NH_4^+ and NO_3^-

/5 marks

2) Provide chemical names for the following compounds.

a) $AlBr_3$ ____________

b) SO_2 ____________

c) Fe_2O_3 ____________

d) $Mg(NO_3)_2$ ____________

e) CCl_4 ____________

/5 marks

3) Provide chemical formulae for the following compounds.

a) Phosphorous pentachloride ____________

b) Calcium fluoride ____________

c) Ammonium sulfide ____________

d) Cupric hydroxide ____________

e) Copper (II) oxide ____________

/5 marks

Part E

1. Draw Lewis structures for

a) sodium atom

b) oxide atom

/4

c) fluoride ion

d) argon

2. Fill in the blanks.

substance	Lewis dot diagram	structural diagram	bond type
O_2			
CCl_4			
MgO			
CS_2			
H_2O			

/10 marks

Total marks for parts B - E **/52 marks**

Part F

Answer the following problems using the correct number of significant figures and show your work.

1) What is the molecular mass of C_2H_6?

/2 marks

2) What is the formula mass of Na_2SO_4?

/2 marks

3) If you have 2.25 g of beryllium metal, how many atoms do you have?

/2 marks

4) How many moles of aluminum hydroxide are in one antacid table containing 400 mg of $Al(OH)_3$?

/4 marks

5) How much would 0.85 moles of $NaHCO_3$ weigh?

/4 marks

Total marks for part F /14

APPENDIX E

NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY

Edmonton

Alberta

Chemistry 101

Pre-Technology

FINAL EXAMINATION

December, 1988

Name: ________________________________

Total possible marks = 150

Examination Instructions:

1. The following sources of information may be used throughout the examination:

   a) density of water at 4°C = 1.000 g/mL

   b) Avogadro's Number = 6.022×10^{23}

   c) The Periodic Table attached at the back of the exam.

   d) Your calculator.

2. Express all your answers to calculations with the correct number of significant figures.

3. Underline your final answer in the calculation questions.

4. Show your work on all calculations to receive full marks on problems.

<u>Part A</u>

Matching Questions: Put the letter corresponding to the correct term in the space provided beside each statement.

______ 1. The process of planning and doing experiments to test an hypothesis.

______ 2. The quantity of matter that a body possesses.

______ 3. A temperature scale having zero degrees at the lowest possible temperature.

______ 4. The mass per unit volume of a substance.

______ 5. The measure of the gravitational attraction between the earth and an object.

______ 6. A prefix used in the metric system having a value of one million.

______ 7. The digits expressing the known precision of a measured quantity.

______ 8. A measure of the intensity of heat.

______ 9. The ratio of the density of a substance to the density of a reference substance.

______ 10. The standard metric unit of length.

Terms for questions 1 - 10.

A) Celsius scale	G) Kelvin scale	M) Scientific method
B) Centimetre	H) Kilo	N) Scientific notation
C) Density	I) Mass	O) Significant figures
D) Foot	J) Mega	P) Specific gravity
E) Investigation	K) Metre	Q) Temperature
f) Joule	L) Micro	R) Weight

/10 marks

_____ 11. A type of chemical reaction in which heat is given off.

_____ 12. A form of matter characterized as having a definite volume and indefinite shape.

_____ 13. Inherent characteristics of a substance that may be determined without altering the composition of that substance.

_____ 14. A change which alters the state of a substance but does not alter composition.

_____ 15. A physical state of matter in which there are almost no attractive forces between the particles.

_____ 16. A type of mixture consisting of two or more physically distinct phases.

_____ 17. A type of mixture that consists of uniform properties throughout.

_____ 18. A convenient method of expressing chemical changes.

_____ 19. Anything that has mass and occupies space.

Terms for questions 11 - 19.

A) Amorphous
B) Chemical change
C) Chemical equations
D) Chemical properties
E) Endothermic
F) Exothermic
G) Gas
H) Heterogeneous
I) Homogeneous
J) Liquid
K) Matter
L) Physical change
M) Physical properties
N) Solid

/9 marks

______ 20. The smallest uncharged individual unit of a compound formed by the union of two or more atoms.

______ 21. A positive or negative electrically charged atom or group of atoms.

______ 22. A substance that cannot be broken down, by chemical means, to simpler substances.

______ 23. The smallest particle of an element that can exist and still be that element.

______ 24. A particle, found in the nucleus, which has a positive charge.

______ 25. A substance containing two or more elements chemically combined in a definite proportion by weight.

______ 26. A particle, not found in the nucleus, which has a negative charge.

______ 27. An element whose properties are intermediate between the properties of metals and non-metals.

Terms for questions 20 - 27.

A)	Aggregate	F)	Element	K)	Molecule
B)	Atom	G)	Ion	L)	Neutron
C)	Chemical Formulae	H)	Metal	M)	Proton
D)	Compound	I)	Metalloid	N)	Symbols
E)	Electron	J)	Mole		

/8 marks

28. Fill in the blanks in the following statements.

a) Potassium is a member of the __________________ family.

b) Bromine belongs to the __________________ family.

c) An atom of aluminum has __________________ electrons in its outer shell (specify the number).

d) The horizontal rows of the table are called ______________.

e) The group B elements are called__________________ elements.

f) When electrons are transferred a(n) ______________ bond forms.

g) When electrons are shared a(n) __________________ bond forms.

/7 marks

Total Marks for Part A = /34 marks

Part B

Multiple Choice Questions: Circle the letter corresponding to the correct answer, fo: each question. Each question is worth one mark. Questions with more than one answer circled will be marked wrong.

1. An atom of atomic number 53 and mass number 127 contains how many neutrons?
   a) 53
   b) 74
   c) 127
   d) 180

2. Which of the following elements is not a member of the Noble Gas family?
   a) Hydrogen
   b) Argon
   c) Krypton
   d) Radon
   e) Xenon

3. Which of the following is a mixture?
   a) Distilled water
   b) Air
   c) Helium
   d) Chromium

4. Which element has six electrons in its outer shell?
   a) Ne
   b) Mg
   c) S
   d) F

5. In Group IVA, the most metallic elements is:
   a) Si
   b) C
   c) Pb
   d) Ge

6. In Group IA the element with the smallest radius is:
   a) H
   b) Rb
   c) Li
   d) Fr

7. Isotopes are:
   a) atoms of the same element having equal numbers of electrons
   b) elements with the same number of neutrons
   c) atoms having the same number of neutrons
   d) atoms of the same element having different atomic numbers

8. The formula of the compound that contains two atoms of nitrogen and five atoms of oxygen per formula is:
   a) $2N_5O$
   b) NO
   c) N_2O_5
   d) N_5O_5

9. Which of the following is an element?
   a) iron
   b) wood
   c) asbestos
   d) water
   e) salt

10. During chemical reactions, metal atoms generally:
    a) become anions
    b) lose electrons
    c) decrease in oxidation number
    d) form covalent bonds

11. Which atom contains a total of 54 electrons?
    a) Mn
    b) Mg
    c) Xe
    d) Ce
    e) Cl

12. In which of the following ways do isotopes of a given element differ?
    a) number of electrons
    b) chemical properties
    c) number of protons
    d) number of neutrons
    e) electronic configuration

13. What is the maximum of electrons that can be in the second energy level?

    a) 2 b) 8 c) 10 e) 18 e) 32

14. Which of the following is the correct electron dot formula for bromine?

    a) Br b) Br c) Br d) Br e) Br

15. Elements in group VIIA of the periodic table are called the:

    a) halogens b) noble gases c) metalloids
    d) alkali metals e) alkaline earth metals

16. Elements in group IIA of the periodic table are called the:

    a) halogens b) noble gases c) metalloids
    d) alkali metals e) alkaline earth metals

17. What is the mass of 0.175 moles of Al atoms?

    a) 0.175 g b) 27.0 g c) 4.72 g
    d) 0.00658 g e) 154 g

18. What is the mass of 9.22×10^{23} atoms of calcium?

    a) 61.4 g b) 1.53 g c) 9.22 g
    d) 40.1 g e) 26.2 g

19. Which of the following elements does not exist naturally as diatomic molecules at room conditions?

a) hydrogen b) sulfur c) nitrogen
d) chlorine e) oxygen

20. An endothermic reaction is one in which:

a) heat is transferred from the reaction to the surroundings.
b) heat is liberated
c) heat is not exchanged
d) heat is taken into the reaction from the surroundings

21. Which symbol is used in chemical equations to indicate a substance in water solution?

a) (s) b) (aq) c) (g) d) (p)

22. An isotope of the element cesium has the symbol $^{137}_{55}Cs$. The number of neutrons in the nucleus of this element is:

a) 55 b) 82 c) 110 d) 137 e) 192

23. Halogens are characterized by which of the following properties?
a) they have the same melting points
b) they have similar physical properties
c) they are chemically inert
d) they tend to form anions
e) they tend to form cations

24. In the following equation which statement is true?

$C_3H_8 + 5\ O_2$ ---------> $4\ H_2O\ +\ 3\ CO_2\ +$ heat

a) the reaction is endothermic
b) mass is conserved
c) moles of reactants equal moles of products
d) the reaction container would get cold

25. Which of the following equations is balanced?

a) $3\ P\ +\ 8\ I_2$ ------> $3\ PI_3$

b) $2\ H_2O_2$ -------> $4\ H_2O\ +\ O_2$

c) $N_2\ +\ 3\ H_2$ ------> $2\ NH_3$

d) $2\ KClO_3$ -------> $2\ KCl\ +\ 6\ O_2$

/25 marks

Part C

1. Name the following:

a) $NaNO_3$ ____________________

b) HCl (aq) ____________________

c) PCl_3 ____________________

d) KCl ____________________

e) $MgCO_3$ ____________________

f) $MgCO_3$ ____________________

g) H_2SO_4 ____________________

h) $FeBr_2$ ____________________

i) NH_4OH ____________________

j) CO ____________________

/10 marks

2. Write the chemical formula for each of the following:

a) Nitric acid ______________________

b) Magnesium sulphate ______________________

c) Sulphur dioxide ______________________

d) Potassium iodide ______________________

e) Calcium hydroxide ______________________

f) Aluminum oxide ______________________

g) Copper (II) oxide ______________________

h) Potassium hydroxide ______________________

i) Sodium phosphate ______________________

j) Phosphoric acid ______________________

/10 marks

Part D

Balance the following equations. (All formulae are correct as written.)

1. $H_2 + Cl_2$ ------> HCl

2. $P + I_2$ ------> PI_3

3. $HNO_3 + Ba(OH)_2$ ------> $Ba(NO_3)_2 + H_2O$

4. $KClO_3$ ------> $KCl + O_2$

5. $NaHCO_3$ ------> $Na_2CO_3 + H_2O + CO_2$

/10 marks

Part E

Complete the following equations.

1. $MgO(s) + HCl(aq) \text{------>}$

2. $Al(s) + H_2SO_4(aq) \text{------>}$

3. $Au(s) + NaCl(aq) \text{------>}$

4. $Fe(s) + CuSO_4(aq) \text{------>}$

5. $AgNO_3(aq) + CaCl_2(aq) \text{------>}$

/10 marks

Part F

Write Lewis electron - dot representations of the following covalent molecules.

a) Cl_2

b) HF

c) H_2S

e) CS_2

d) CCl_4

/10 marks

Total Marks for Parts B - F = /75 marks

Part G

1. Complete the following table with the appropriate data for each isotope given.

Atomic Number	Mass Number	Symbol of Element	Number of Protons	Number of Neutrons	Number of Electrons	Isotopic Notation
12	24					
				34		$^{63}_{29}Cu$
	37				17	

/17 marks

In all calculations, express your answer with the correct number of significant figures.

2. Express the following numbers in scientific notation to two decimal places.

   a) 0.00467

   b) 9,547,253

   c) 10.0

/3 marks

3. Make the following conversions:

a) 769 kg to mg

/2 marks

b) -21°C to K

/2 marks

4. a) Calculate the mass of mercury in a container if the sample of mercury has a volume of 252 mL and a density of 13.55 g/mL.

/3 marks

b) What is the specific gravity of the mercury in part a)?

/2 marks

5. Make the following conversions:

a) 8.66 mol Cu to grams Cu

b) 28.4 g S to moles S

c) 42.4 g Mg to atoms Mg

/6 marks

6. Calculate the formula masses for the compounds listed.

a) $CaCl_2$

b) $Al(OH)_3$

c) S_2F_{10}

/6 marks

Total Marks Part G = /41 marks

Merry Christmas to All