AN EVALUATION OF THE NATURE AND OBJECTIVES OF CHEMISTRY PRACTICAL LESSONS AT THE KATSINA COLLEGE OF ARTS SCIENCE AND TECHNOLOGY ZARIA

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The undersigned certify that they have read, and recommend to the Faculty Board of Education for acceptance an Independent research study entitled:

An Evaluation of the nature and objectives of chemistry practical lessons at the Katsina College of Arts Science and Technology Zaria

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ABSTRACT

This study was carried out to evaluate the nature and objectives of chemistry practical lessons at the Katsina College of Arts Science and Technology Zaria.

Previous related studies have indicated that the nature of any chemistry practical lesson can be fitted within a continuum with the traditional approach at one end and the modern investigatory approach at the other end. The following variables were used to evaluate the nature of chemistry practical lessons.

(1) Time allocated to practical lessons as compared to that allocated to theory lessons
(2) Relationship between theory lessons and practical work.
(3) Responsibility for designing experiments
(4) Responsibility for interpreting data obtained from experiments.

In the traditional approach very little time is allocated to practical lessons as compared to theory lessons and experiments are designed by teachers and

teachers help in interpreting data. The converse is the case in the modern investigatory approach.

From the previous studies on the objectives of practical lessons three phases to an experiment can be identified viz

(i) the road to the experiment

(ii) the experiment

(iii) the conclusion to the experiment.

A comprehensive list of practical objectives have been identified for each phase of the experiment. The work of Swain (1974) is a classic example. Swain's comprehensive list of practical objectives were modified in this study and the modified version was used as checklist in evaluating each of the three phases to an experiment.

The chemistry practical work carried out in the college for three consequctive sessions (1977/78, 1978/79 and 1979/80) as contained in the schedules of practical work was used as main source of information. Laboratory exercises were classified into experimental units. Each experimental unit was defined in terms of the cognitive and manipulative skills demanded by the experiments.

The nature of practical work was evaluated using the variables identified earlier on, while the objectives of practical work was evaluated using the modified version of Swain's comprehensive list of practical objectives.

Major Findings

The study showed that the chemistry practical lessons conducted in the college was largely traditional in nature. There was little or no correlation between theory lessons and practical work. Teachers tended to usurp students role in designing experiments and in interpreting data collected from experiments.

The study also revealed the fact that while satisfactory opportunities were made available for students to develop a wide variety of desirable abilities at the 'experiment phase' of a laboratory exercise, the provisions made for developing a wide range of abilities classified under the two other phases to an experiment viz. the road to the experiment and the conclusion to the experiments are largely unsatisfactory.

The writer observes that what majority of developing countries expect from science education is not producing a generation of technicians good at servicing imported technology but a new generation of original scientists and technologist able to make unique contribution to science and capable of developing local technology to solve a number of peculiar national problems.

This new goal of science education in the developing countries requires opportunities for developing in students creative minds and intuitive mode of thinking. The traditional approach to practical lessons which is still popular in schools is in the writers view grossly inadequate to meet the nations aspirations.

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.....
Timothy O. Alabi
K.C.A.S.T. Zaria
August 1980.

DEDICATION

This work is dedicated to

My wife

My Parents

and

My Teachers

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I am sincerely grateful to Dr. D.P. Brown lecturer in Science Education, in the Department of Education of the Ahmadu Bello University Zaria for devoting much of his time in supervising this study. His intellectual guidance, criticisms and suggestions have contributed in no small way to the successful completion of this work.

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Nigeria attaches great importance to science and technological education. Generous grants have been made available by Federa and State Governments for the establishment of colleges of Science and Technology, the expansion of existing Science Facilities in schools and the introduction of science courses in schools where these are non-existent. There are in addition generous scholarships for science and technology courses.

The emphasis on science and technological education in Nigeria (as well as in many other developing countries) is apparently due to the realisation of the great advantages which science and technology has conferred on the highly industrialised western world and the role science education can play in producing adequate scientific manpower for "the dynamic Nigerian society on the March towards industrial and technological progress" - Adaralegbe (1969).

Developing countries like Nigeria have tended to emphasise the utiliarian values of science and what applied science contributes to our practical human needs like food, shelter health etc. The other aspect of science as the greatest intellectual and cultural achievement of modern man is too often neglected. Odhiambo (1972) pointed out that:

> When African leaders consider science in terms of national development they usually have in mind three aspects:
>
> (1) The industrial production of goods following procedures already worked out in other countries.
>
> (2) The application of existing scientific knowledge to local raw materials leading to industrial processing.
>
> (3) Oriented fundamental research on problems peculiar to the country which may lead in fairly short-term to worth while dividends (in agriculture medicine etc.)

These objectives which were popular in the early sixties were based on the concept of transfer of technology (or technological dependence) as a means of rapid industrialisation and anticipated technological progress in the developing countries. The goals of science education were implicitly derived from these objectives.

Science teaching was directed towards servicing imported technology and developing what Schwab described as 'stable enquiry'. Schwab (1962) has used the term 'stable enquiry' to refer to

> researches which receive their conceptual principles from others and treat these principles as matters of fact, not matters for test ..... in each stable enquiry the investigator's eye is on the immediate outcome, the filling in of a particular blank place in knowledge. The blank place itself and the way to go about filling it are conferred by the principles of enquiry.

If the goal of science education is limited to the development of technology and promotion of stable enquiry in science, a philosophical position about the nature of science has been adopted. That philosophical position recognises the infallibility of the intellectual foundations of technology and stable enquiry. Scientific principles, theories and concepts which are the bed rock of technology and stable enquiry are regarded as truths reliable and unchanging. This assumption has led to a traditional method of teaching science in which teachers have as Schwab (1962) reported.

> tended to treat only the outcomes, the conclusion of enquiry divorced from the

data which support them and the conceptual frames which define and limit their validity.

The consequencies of such philosophical position on the nature of science is to convey a false image of science to the learners. Science is presented as a body of knowledge verified and certain. The incertitudes, probabilities and revisionary characteristics of scientific knowledge are not presented. Science courses present rhetorics of conclusions without reference to the supporting data and the limitations.

Science is taught more as a list of achievements rather than as human intellectual activity seeking to refine man's understanding of the natural world. Emphasis is more upon describing what is known that how we know. While opportunities may be made available for the development of analytic method of thinking little opportunities exist for developing intuitive methods of thinking which are useful for creativity.

The net effect on the students is the development of a climate of opinion unfavourable to the study of science. Infact a notion is already gaining ground in many developing countries that science subjects are

reserved for the highly gifted students. If the experiences of developed countries in science education is anything to go by we can postulate that unless something urgent is done to re-structure science courses, there will be significant decrease in the number of students willing to take advantage of the facilities made available in science and technology and this, despite increasing government investment in science.

The need for a change in the philosophy of science education began to be felt towards the close of the sixties. Two important factors are largely responsible - political and international trends in science curriculum studies.

The hope for rapid industrailisation and general economic development through transfer of technology has over the years proved illusive for the developing countries. One of the reasons often given is difficult access to technology. Technology is largely in private ownership in the highly industrialised western world. It is also a source of monopolitist advantage. This has

made the cost of imported technology highly prohibitive due to 'monopoly pricing' and this has adversely affected the balance of payments for most developing countries.

Developing countries have also discovered that imported technology is in many cases in-appropriate to local requirements and conditions. There is also the realisation that technological aids from other countries usually come with idealogical strings attached.

These conditions have led to scepticism about technological dependence and the realisation of the need for developing a nation's own technology as a step toward scientific technological and economic progress. Developing a nation's technology calls for a new approach to science education. Science education will need to foster creativity, intuitive methods of thinking and what Schwab described as "fluid enquiry". These will provide the intellectical foundations for the development of local technology.

Schwab (1962) has described "fluid enquiry" as one in which

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Schwab (1962) has described "fluid enquiry" as one in which

> the aim of research is to test the principles and ultimately to revise or invent replacements for them. The goal is not the immediate

> knowledge of the subject which use of the principles may lead to, but discovery of their limitations as intellectual tools of long term programmes of stable research.

The goal of science education in developing countries should be guided by the need to produce

> those who are potentially consumers of scientific knowledge and those whose potential interest and special competences distinquish them as possible maker of that knowledge - Schwab (1962).

Such a goal of science education will ensure the production of the much needed technical and scientific manpower as well as a new generation of scientists who will undertake tests of scientific principles and develop new conceptual frame works on which the nations technology can be developed. Such a goal of science education will lead to scienctific and technological independence and also give a valid image of science to non-scientists. Science courses based on such goals will incoporate the development of attitudes process skills and concepts.

The wave of curriculum development activities in the sciences which started in the U.S.A. and in

the U.K. in the sixties were designed to promote both fluid enquiry and stable enquiry in the study of science. Some of these programmes include: Science a process approach (S.A.P.A.)
Science Curriculum Improvement Study (S.C.I.S.)
Chemical Bond Approach (C.B.A.)
Chemical Education materials study (C.H.E.M.)
Biological Sciences Curriculum Study (B.S.C.S.
Nuffield science teaching project.

These programmes and many newer ones in science are identical in emphasising the experimental nature of science. Great emphasis is therefore placed on students practical work which forms the basis for science teaching. This is borne out of the conviction that if science must be learned effectively science must be experienced.

It has often been said that science is not really science unless it is accompanied by experimentation and laboratory work. In a broad sense, the laboratory becomes the central feature in science teaching. The importance of such a central position necessitates a

reappraisal of past practice and stimulates the imagination to explore the potential of the school science laboratory.

The traditional science laboratory lesson have been derisively described as 'cook book'. In such laboratory classes the teacher decides which experiments are to be run, what data to collect and sometimes how to interprete the data. The primary purpose of such "cook book" laboratory lessons appears to be illustration and vertification of theoretical concepts already taught in class. The question can be raised as to whether the laboratory is used most effectively when its functions are limited to illustration and vertification.

Commenting on such "cook book" laboratory lessons Mathewson (1967) observed that the cook book laboratory lessons are unsatisfactory

> not because we are presenting the wrong operations - it is because it is not exciting, challenging, cogent. It provides no opportunity for genuine creative thinking on the part of the students.

Curriculum improvement activities in Nigeria have

attempted to break away from these 'cook book' laboratory experiences and investigative approaches have been adopted in such programmes like:

(i) the Nigerian Integrated Science Project (NISP) for first two years of secondary education

(ii) the new Chemistry, Biology and Physics courses for Forms III-V of the Nigerian Secondary Schools. The course was prepared by the Science Teachers Association of Nigeria (STAN) in collaboration with the comparative Education study and Adaption Centre (CESAC) and the West African Examination Council (WABC).

Curriculum improvement activities in the sixth form are limited. The Interim Joint Matriculation Board (IJMB) of the Ahmadu Bello University (A.B.U.) has prepared courses of study equivalent to those of the traditional sixth form courses. The I.J.M.B. programme has introduced many innovations some of which are:

(i) an element of internal assessment by teachers has been introduced. The continous assessment by teachers account for about 30% of the final assessment.

(ii) Absence of external practical examinations in science except in physics where it has recently been introduced.

Without the pressure of external examination in practical work, science teachers teaching I.J.M.B. courses are given the freedom to organise their practical lessons in a manner that will help achieve the new goal of science education. It is freedom that calls for industry imagination and cooperative effort on the part of science teachers.

1.2 STATEMENT OF THE PROBLEM.

The purpose of this study is to evaluate the nature and objectives of chemistry practical lessons at the Katsina College of Arts Science and Technology Zaria, specifically the researcher wants to find answers to the following important questions.

1. What is the ratio of time allocated to chemistry practical lessons as compared to that allocated to theory lessons?
2. a. What is the relationship between what was leannt in theory lessons and what was done in practical class?
   b. Do practical lessons lead or lag theory lessons?
3. Who designs the procedure to be followed in an experiment - Teacher or student?
4. Who interpretes the observation or data obtained from the experiment - Teacher or Student?
5. What provisions are made to ensure that students understand the theoretical principles and logic on which the experimental procedures was based?
6. What manipulative and cognitive skills are demanded by the experiments in chemistry practicals?
7. What type of conclusions are demanded from students after experiments have been carried out?

1.3 SIGNIFICANCE OF THE STUDY

The science practical lesson is an educational device that is used misused and overused without much

questioniniong. In view of the high educational potential of science practical lessons and considering the huge investments made in science laboratories there is need for constant evaluation of the nature and objectives of science practical lessons. Such an evaluation will provide invaluable feedback on the role practical lessons play in the teaching of science and in the development of the different categories of scientific and technological manpower for the nation.

The objectives of practical lessons in I.J.M.B. courses are not stated. The change in behaviour expected from students after the practical course has been taken is therefore not planned for. Nevertheless practical lessons have been organised year in year out without clearly defined objective. The dangers in such practise are well illustrated in the proverb credited to Mager (1962)

> If you are not sure where you're going,
> you're liable to end up some place
> else. - and not even know it.

This study is conducted to investigate what the implict objectives of practical lessons are and offer suggestions

on how to make our objectives explicit and relevant to the goals of science education.

1.4 LIMITATION OF THE STUDY

This study was limited to Chemistry practical lessons as conducted in Katsina College of Arts Science and Technology Zaria. Other colleges offering I.J.M.B. courses were not included. Findings of the study are valid only for the college and for Chemistry in particular. This limitation is self imposed since the aim of the study is the improvement of science teaching in general and chemistry teaching in particular at the Katsina College of Arts Science and Technology.

To expand the scope of the study would have meant an evaluation of science practical lessons in the I.J.M.B. courses.

1.5 DEFINITION OF TERMS.

PRACTICAL CLASS.

This is a lesson in which the student himself manipulates real objects according to some pre-established,

pretested scheme under the supervision of a teacher. The exercises are called 'experiments' but they are not really scientific experiments because the outcomes are known and their purpose is educational not scientific.

PRACTICAL OBJECTIVE

A statement of intended outcome in practical work after a suitable course has been taken. The statement is constructed in behavioural terms.

CHAPTER II

REVIEW OF RELATED LITERATURE

The importance of practical lessons in the teaching of chemistry is generally accepted by most educators. There is however diversity of opinion as to what the nature and objectives of practical lessons should be. This has led to a variety of activities in the name of practical lessons in chemistry.

It is not possible to describe all the different approaches to chemistry practical lessons encountered in schools. Most approaches can be fitted in a continuum between 'traditional' and 'modern' approaches. The goals of practical lessons in the modern science course focus upon the inquiry, discovery, process or methodological phase of science and upon its intellectual components. This is in contrast to the traditional approach in which the laboratory is primarily used to illustrate, demonstrate or verify known concepts and laws.

There are quite a number of science educators philosophers and psychologists who advocate the modern investigatory - experimental approaches to science practical lessons. Schwab an advocate of enquiry teaching and learning of science has emphasised the need for laboratory work to lead and not to lag the classroom phase of science teaching. When this is done Schwab (1962) noted,

> The laboratory ceases to be a place where statements already learned are merely illustrated and where perception of phenomena takes places within the restrictive structuring of terms and concepts already laid-down. ..... The laboratory manual which tells the student what to do and what to expect is replaced by more permissive and open material.

Bruner (1960) has outlined four psychological advantages in using discovery approach to science teaching. They are:

(1) Increase in intellectual potency - development of the mind through mental processes involved in discovery activities.

(2) Shift from extrinsic to intrinsic motives -

the discovery of scientific concepts by the learner himself is self motivating.

(3) Learning the heuristics of discovery - helps students learn how to learn in an investigative way.

(4) Aids conservation of memory - increases memory retention.

Watson (1960) has also observed that the discovery approach to science teaching makes instruction student centered and postulates that

> "the greater the student involvement the greater the learning.

In the traditional approach to science practicals on the other hand, the emphasis is generally on how to do the experiment and arrive at results known before hand. Very little importance is given to understanding the principles or logic underlying the experimental approach.

Quite a large number of practising science teachers hold the view that the nature and objectives of practical work are dictated to a greater or lesser extent by one or more constraints either imposed by the system or desired by those responsible for conducting

the practical lesson. Example of constraint that might control the nature of practical lessons are

(1) logistics

(2) availability of equipment

(3) insufficient time allocation for practical lessons.

(4) the kinds of experiments chosen

(5) Examination requirements

Commenting on the influence of external examinations on the methodology used by the science teacher, the journal of STAN (1975) in its editorial pointed out that

> Even though good science teachers believe that 'training' students primarily to pass examination is not the best approach to science teaching yet, this method is commonly practised. The implication of this is the obvious point that have been made by several science educators. Examinations to a large extent set the tone of teaching whether we like it or not.

One consequence of the influence of examination on practical work was reported by Alabi (1979) when he observed that:

> Too much pre-eminence is given to theory almost to the utter neglect of meaningful

> experiences that can be obtained from practical work. The practical works often follow the lines of a predetermined syllabus whose content and sequence may have very little bearing to what was currently learnt in theory classes.

At the Katsina College of Arts Science and Technology Zaria there is no external examination in chemistry practicals. The chemistry teachers have a choice (within limits of other contraints of the system) to organise either a tradition 'cook book' practical lessons or the modern discovery practical lesson.

The type of practical approach a teacher decides to adopt usually depends on a number of factors. Some of these include,

(i) the teachers view of the nature of science
(ii) his overal aims and objectives in teaching science.

Until recently the educational objectives of practical lessons were often vague and seldom stated. These statements of objectives when they are made are at best a consensus of the opinion of experienced science teachers. This however does not decrease their

valitity, since one of the main features of any classification of objectives should be that they are agreed upon by practising teachers to be desirable and recognisable outcomes of education. The earliest methods of designing a list of objectives for practical lessons have followed this method.

Kerr (1963) collected ten statements from published reports on science teaching method. Keer then carried out a survey of the relative importance attached to the ten listed aims of practical lessons by science teachers in England and Wales. His study showed that the following objectives of practical work were highly rated:

(1) To encourage accurate observation and careful recording.

(2) To elucidate the theoretical work so as to aid comprehension.

(3) To be an integral part of the process of finding facts by investigation and arriving at principles.

(4) To promote simple common sense scientific methods of thought.

Objectives of practical work which were rated very low include:

(1) To arouse and maintain interest in the subject

(2) To fit the requirement of practical examination

(3) To give training in problem solving.

West (1972) re-investigated Kerr's findings on the basis of the wave of curriculum development activities in Britain. His findings showed a significant shift in teachers emphasis on some of the objectives. Objectives which were then highly rated included:

(i) developing scientific thought

(ii) part of process of fact finding

(iii) arouse and maintain interest.

Mathewson (1967) has suggested that students practical work in science should be based on

> a delineation of those skills, knowledge, competencies and attitudes that we believe the student should have from the course.

This means that the objectives of science practical lessons should be stated clearly. Several classified

statements of the practical abilities which chemistry students can be expected to attain are now published. A typical example being one from the Joint Matriculation Board (JMB 1974) of Great Britain. Five qualities are to be assessed at the advanced level chemistry practical examination. These objectives include

(1) Skill in observation and accurate recording of observations.

(2) Ability to interprete practical experience.

(3) Ability to plan and carry out experiments.

(4) The possession of appropriate manipulative skills.

(5) Attitudes to practical work.

These general statements are subsequently defined in more operational terms.

It is well known that the objectives of any course are unlikely to be achieved unless in addition to being well understood by the teachers they are fully reflected in his methods and assessment. Johnstone and Wood (1977) postulated that if the stated objectives of practical lessons in chemistry are a valid set, then

> the teacher should be able to communicate his view of these objective via each experiment and teachers objective and pupils objectives should coincide.

Their study was an evaluation by teachers and students to determine whether the 'course objectives' in a set of chemistry practicals were achieved. Out of the ten statements of course objectives the following objectives were considered achieved by teachers and students as a result of the practical lessons. These objectives of chemistry practical lessons include:

As a result of the series of experiment.

(1) Students realised that chemical theory derived from observation.

(ii) students were able to draw justifiable conclusions from personal observations.

(iii) students acquired skills and practical techniques.

(iv) helped students to understand a theory previously taught in class.

Whitfield and Eggleston (1968) have developed an elaborate list of practical abilities in a hierarchical

order along the lines of Bloom's taxomony. The list ranges from simple cognitive abilities such as knowledge of appratus and procedures to psychomotor abilities such as ability to observe and record.

The problem of designing a comprehensive list of objectives is not an easy one. Swain (1974) has suggested that there are three possible ways for designing such a list:

(1) It is possible to adopt a Bloomian type analysis as proposed by Whitfield and Eggleston into domains such as cognitive psychomotor etc.

(2) It is possible to canvass opinion as to the most popular objectives.

(3) Alternatively it is possible to approach the objectives from the practical situation and analyse "the experiment" itself and use objectives given by previous authors sometimes modified to produce a new list.

Swain (1974) observed that

> The last alternative seems to be the most satisfactory approach since the Bloomian approach can be divorced from the teaching

situation and the canvassing of opinion has been used several times and only reflects the mood of teachers at the time of inquiry.

In Swains (1974) survey all published statements of objectives of practical lessons were classified under three main units.

1. The road to the experiment;
   This is concerned with objectives related to the purpose, the planning and the viable set up of the experiment.
2. The experiment proper:
   this includes all statements of objectives related to skills in manipulation observation and recording, of observation.
3. The conclusion to the experiment;
   this unit includes statements of objectives relating to analysis interpretation and comments on data.

To evaluate a programme some kind of yardstick is needed. An evaluation of the objectives of chemistry practical lessons therefore requires valid yardstick. The yardstick should be a list of objectives for

practical lessons which are consistent with the specific characteristic of chemistry as a discipline and which are agreed to by practising teachers as desirable and recogniable outcomes of the programme.

The modern trend to evaluation of an educational programme whose objectives are clearly stated is to administer a performance test on students who have undertaken the course of study. The performance test are carefully designed to find out whether student did perform to the expectation of the course objectives.

This particular approach to evaluation has not been used in this study. This is because of lack of stated objectives for chemistry practical lessons in the college. Infact the study had to design a comprehensive list of objectives by an analysis of the 'experiments' provided in the course using Swain's method.

Swain's method contains a classified suggested check list that can help identify the strong points of the programme as well as those points that need to be strengthened. It is a modified form of Swain's approach that is used in this study.

CHAPTER III

THE METHOD AND DESIGN OF THE STUDY

The study was designed to evaluate the nature and objectives of chemistry practical lessons at the Katsina College of Arts Science and Technology Zaria. The practical schedule prepared by the Chemistry Section of the College for the weekly conduct of practical lessons was used as the main source of information in the evaluation of the nature and objectives of practical lessons.

This practical schedules which provides a record of practical work carried out on a weekly basis also provided instructions and guidance to teachers in the conduct of their practical lessons. The practical schedules were therefore considered as a more autenthic record of actual laboratory work carried out than the I.J.M.B. syllabus for practical chemistry.

The practical schedules for three consequtive sessions were used (1977/78; 1978/79; 1979/80). The

practical schedules used included those pareparcd for I.J.M.B. year one students and those for I.J.M.B. year two students during the same period of study.

To evaluate the nature and objectives of chemistry practical lessons provided in the college, the practical schedules for the three sessions under review were studied to see the scope and variety of laboratory experiences provided. The exercises in the practical schedule were then classified into experimental units. Each experimental unit is defined in terms of the cognitive and manipulative skills required in carrying out the laboratory exercise. Four experimental units were identified.

1. Tirimetric analysis
   (a) acid base titration
   (b) redox titration.
2. Qualitative Analysis
   (a) qualitative inorganic analysis
   (b) qualitative tests of functual groups in organic chemistry.
3. Selected exercises for illustrating certain principles of physical chemistry.

4. Selected Organic and Inorganic preparations.

3.1 EVALUATION OF THE NATURE OF CHEMISTRY PRACTICAL LESSONS.

The nature of chemistry practical lessons encountered vary from one laboratory to another. Lippincott (1975) has grouped the nature of experimental patterns commonly encountered in school laboratories into four:

(1) The traditional exercise approach

(2) Approaches in which the student attempts to discover the concepts for themselves.

(3) Individual student project or group contribution approaches. In the latter each student contributes one or more pieces of data or observations to the solution of a group problem.

(4) The student selection approach where students choose weather they will pursue a given experiment in more depth or go on to try a new experiment and master a new technique.

Lippincott went further to analyse the philosophical models or patterns used in individual experiments or in designing the laboratory as a whole. Five models

were identified and they include:

(1) The traditional observation - interpretation type of experiment.

(2) Programmes in which the student designs his own experiments.

(3) Those in which technique and numerical answers have primacy.

(4) Others in which illustration of a principle or something judged to be highly relevant are featured.

(5) The independent investigator pattern.

To evaluate the nature of chemistry practical lessons, each of the experimental units was assessed on the following points:

(1) The laboratory sessions allocated to each experimental unit and a comparison of time allocated to theory and practical lessons.

(2) The sequence of the experiments to see if there is any relationship between theory and practical lessons.

(3) The responsibility for designing the procedure

or technique for carrying out laboratory exercises - teachers or student.?

4. Treatment of observation; data etc. student's responsibility or teacher provides guidelines?

The writer who has been actively involved in chemistry teaching in the college carried out the assessment and presented his assessment to two other science educators involved in chemistry teaching in other institutions for validation. Specimen copies of practical schedules in chemistry can be found in the Appendix.

3.2 EVALUATION OF THE OBJECTIVES OF CHEMISTRY PRACTICAL LESSONS.

Swain (1974) has suggested that an experiment needs three main units of time viz.

(1) The road to the experiment

(2) The experiment

(3) The conclusion of the experiment

Venkatachelam and Rudolph (1974) have proposed two phases to an experiment in chemistry.

(1) The learning cycle which consists of:

(i) Reading assignments and discussions to

provide extensive background for the experiment.

(ii) The 'cook book' experiment to familiarise students with equipment and technique and to reinforce the theoretical principles presented in the reading assignment.

(2) The challenge cycle which consists of a variation of the 'cook book' laboratory experiment in terms of open-ended questions.

Both approaches are identical in that they recognise the need for

(i) a pre-laboratory instruction on the idea to be explored.

(ii) the experimentation phase and

(iii) the conclusion to the experiment in which data is classified interpreted and used to answer basic questions on the underlying theoretical concepts of the practical lesson.

This study has adopted the three phases approach to a laboratory lesson in evaluating the objectives of

practical lesson. Swain's comprehensive list of practical objectives were considered too elaborate for use as Checklist for evaluating objectives of chemistry practical lessons at the advanced level. A modified form of Swain's list of practical objectives was constructed. All the objectives considered not applicable at the advance level of chemistry practical were eliminated from Swain's list while some other desirable objectives from the work of Venkatachelam and Rudolph were included, in the modified version of Swain's list.

Each experimental unit was analysed to find out whether it provided opportunities for students to develop a classified list of practicals abilities given below:

Phase I THE ROAD TO THE EXPERIMENT.

1. Ability to comprehend the purpose of the experiment.
2. Ability to plan an experiment.
   (i) ability to analyse the practical problem into its components parts.
   (ii) ability to device/select a procedure/technique.
   (iii) ability to recognise limitations and possible sources of error in (ii).

PHASE II THE EXPERIMENT

3. ability to obtain a viable experimental set-up.
   (i) ability to follow and comprehend written/ verbal instructions.
   (ii) ability to select and assemble apparatus to perform a standard/novel function.
4. Manipulation.
   (i) ability to use familiar/unfamiliar apparatus/ materials.
   (ii) ability to implement familiar/unfamiliar procedures.
5. Observation.
   (i) ability to make accurate qualitative observation.
   (ii) ability to make accurate quantitative observation.
6. Recording.
   (i) ability to record accurately the experimental data obtained.

PHASE III THE CONCLUSION

7. Ability to analyse and interprete the experiment.
   (i) ability to arrange/organise/classify data obtained in tabular/diagramatic/graphical form.
   (ii) Ability to interprete results and drawn conclusion.
8. Ability to use information obtained from experiment to answer questions on underlying theoretical principles.

In evaluating the practical objectives of each experimental unit, the practical schedules were studied to see whether the practical schedules provided opportunities for a pre-laboratory instruction. Specifically, the writer is interested in finding out whether the practical schedules had provisions for students to obtain adequate theoretical background to comprehend the purpose of the experiment. This can be in the form of background reading material assigned or contained in practical manuals which should be given in advance of practical lessons or reading assignment which are then reinforced by oral

presentation by the teacher or an introductory lecture in the theory class on the idea to be explored in practical lesson.

The other phases of laboratory lessons namely the experiment and the conclusion to the experiment were evaluated using Allison's method (1977). In this method the objectives of an experiment is determined by an analysis of the skills and abilities the exercise demands from the student. The objectives identified are then classified using the modified Swain's method.

CHAPTER IV

RESULTS AND ANALYSIS OF DATA

EVALUATION OF THE NATURE OF CHEMISTRY PRACTICAL LESSONS.

4.1 COMPARISON OF THE TIME ALLOCATED TO THEORY LESSONS AND THE DIFFERENT EXPERIMENTAL UNITS IN PRACTICAL LESSONS.

Table I shows a disproportionate time allocation between theory and practical lessons. While each student is exposed to six hours of theory lessons per week the student has only a two-hour laboratory session per week. This reflects the relative importance attached to theory lessons compared to practical lessons. This situation exist at a period when the Slogans - 'Practical work should form the basis of Science teaching' and 'science teaching becomes science through experiments' are loud and frequent. The writer is aware of some of the constraints imposed by the system on the organisation of practical lessons in the college. Some of these constraints include:

1. Increasing enrollments leading to overcrowding of laboratory space.
2. Logistics
3. Specifications of the chemistry practical syllabus.

It appears that the role of chemistry practical lessons in the college is mainly to fit the requirements of the I.J.M.B. syllabus.

TABLE I

TIME ALLOCATED TO THEORY AND PRACTICAL LESSONS PER WEEK.

MODE OF INSTRUCTION	HOURS PER STUDENT PER WEEK
PRACTICAL LESSON	1 LABORATORY SESSION OF 2 HOURS
THEORY LESSON	6 HOURS.

TABLE II

TIME ALLOCATED TO EACH EXPERIMENTAL UNIT IN PRACTICAL LESSONS.

EXPERIMENTAL UNITS	LABORATORY SESSIONS ALOTED	NO.OF HOURS
1. TITRIMETRIC ANALYSIS		
(a) Acid base titration	6	12
(b) Redox titration	8	16
2. QUALITATIVE ANALYSIS		
Inorganic	10	20
Organic	8	16
3. PHYSICAL CHEMISTRY		
Practical exercises	9	18
4. PREPARATION OF COMPOUNDS		
Organic	1	2
Inorganic	1	2
TOTAL	43 SESSIONS	86HRS

Table II which shows the time allocated to each experimental unit tends to lend weight to this observation. The average of 43 laboratory sessions of practical work available in a two year I.J.M.B. course are distributed

to cover most of the suggested experiments in the I.J.M.B. chemistry practical syllabus. The flexibility anticipated by the absence of external examination in chemistry practicals gives way to rigid practical organisation imposed by the desire to cover most of the experiments listed in the I.J.M.B. chemistry practical syllabus.

4.2 THE SEQUENCE OF THE EXPERIMENTS TO SEE IF THERE IS ANY RELATIONSHIP BETWEEN THEORY AND PRACTICAL LESSONS.

Table III shows a comparison of the sequence of experiments carried out in practical lessons with the chemical concepts taught in the same period in theory class. The table shows that in most of the cases there is no relevance between what was taught in theory class and the type of experiments carried out in the laboratory. It appears that in organising practical lessons in chemistry, the symbiotic relation that should exist between theory and laboratory activities is ignored. While theory and practical lessons are

TABLE III

COMPARISON OF THE SEQUENCE OF EXPERIMENTS IN PRACTICAL LESSONS AND TOPICS IN THEORY LESSONS.

EXPERIMENT IN PRACTICAL	TIME ALLOCATED	TOPICS IN THEORY	TIME ALLOCATED
1. Qualitative Inorganic Analysis	10 weeks	1. Atoms molecules compounds 2. Gross features of Atomic structure 3. Chemical bonding. 4. Stoichimetry/ Oxidation Reduction. 5. Gas liquid and solid.	60 hours
2. (a) Acid-base titration	6 weeks	6. Crystals 7. Thermochemistry 8. Chemical Kinetics	36 hours
(b) Redox titration	8 weeks	9. Chemical Equilibrium 10. Acid bases salts 11. Ionic equilibria	48 hours
3. Experiments in Physical Chemistry	9 weeks	Physical/Inorganic and organic topics	54 hours
4. Qualitative Organic analysis	7 weeks	Inorganic and organic topic	42 hours
5. Organic and Inorganic preparation.	2 weeks	Inorganic and Organic topics	4 hours

mutually supportive and in terms of learning science are not distinquishable from each other, the lack of relevance between theory and practical lessons suggest that practical work in chemistry in the college is considered merely as an illustrative appendage to the course theory.

4.3 DESIGNING EXPERIMENTS AND INTERPRETING RESULTS OF EXPERIMENTS.

Table IV shows that the design of the laboratory work in all the experimental units of the chemistry practical work is dedided by teachers and communicated in form of written/oral instructions to be carried out by the student.

Also elaborate guidelines are provided in interpreting results in experimental units like titrimetric analysis and physical chemistry experiments. Students are however allowed to interprete their observation in both qualtitative inorganic and organic analysis.

The experimental unit on preparations in organic and inorganic does not appear to have provision for interpretation of observations.

TABLE IV SUMMARY OF THE RESPONSIBILITY FOR DESIGNING EXPERIMENTS AND FOR INTERPRETING EXPERIMENTAL DATA.

EXPERIMENTAL UNITS	EXPERIMENTAL DESIGN	DATA INTERPRETED BY
1. Titrimetric analysis Acid base titration Redox titration.	Teacher	Teacher and Student
2. Qualitative Analysis Inorganic Organic	Teacher	Student
3. Physical Chemistry Practical exercise	Teacher	Teacher
4. Preparations Organic Inorganic	Teacher	-

Since students are not given opportunities directly or indirectly to device/select a procedure/technique for carrying out their experiments, students are not provided with opportunities to develop intuitive thinking necessary for creativity. It is reasonable to say that students should be given opportunities to learn much more than the mere knack of following directions in a

laboratory lesson.

It is possible in general to classify each experimental unit in chemistry practical course on a philosophical model as proposed by Lippincott (1975) on the basis of the findings summarised in Table I-IV.

This classification is presented in Table V.

TABLE V

THE PHILOSOPHICAL NATURE OF THE DIFFERENT EXPERIMENTAL UNITS.

EXPERIMENTAL UNITS	PHILOSOPHICAL MODEL
1. Titrimetric Analysis (a) Acid base titration (b) Redox tritaation	Technique and numerical answers have primacy
2. Qualitative Analysis Inorganic Organic	The traditional observation Interpretation type of the experiment.
3. Physical chemistry Practical exercise	Illustration of principles Judged to be highly relevant in Physical Chemistry.
4. Preparation Organic Inorganic	Illustration of Principles

EVALUATION OF THE OBJECTIVES OF CHEMISTRY PRACTICAL LESSONS.

4.4 ROAD INTO THE EXPERIMENT:

Table VI shows the main approaches adopted to provide suitable theoretical background to enable students comprehend the purpose of the experiment. It is significant that only in qualitative inorganic and organic analysis are pre-laboratory instruction given in form of lecture or printed written materials. For inorganic qualitative analysis two practical sessions are reserved for providing pre-laboratory instructions - one laboratory session for outling tests and carrying out demonstrations of anion analysis another laboratory session for teaching tests and demonstrating cation analysis. For organic analysis detailed handouts are pared for systematic analysis of elements and functional groups in organic chemistry. The handouts which are distributed to students contains detailed instructions on what to do and what to observe.

The titrimetric experimental unit has its pre-laboratory instruction in form of written or oral

instruction or discussions before actual practical lessons. Practical exercises on physical chemistry and preparations of organic and inorganic compounds have handouts which contain adequate theoretical backgrounds for the practical lessons. However these handout are only given out during the laboratory session in which the practical work is to be done, students are then compelled to use the first ten to fifteen minutes of the time for practical class to

TABLE VI:

MAIN APPROACHES ADOPTED TO PROVIDE THEORETICAL BACKGROUND FOR PRACTICAL LESSONS.

EXPERIMENTAL UNITS	RELEVANT LECTURE OR READING MATERIAL PROVIDED ABOUT EXPERIMENT IN ADVANCE	THEORETICAL BACKGROUND FOR EXPERIMENT ONLY PROVIDED DURING PRACTICAL SESSION
1. TITRIMETRIC ANALYSIS		
(a) Acid Base titration	No	Yes
(b) Redox titration	No	Yes
2. Qualitative Analysis		
(a) Inorganic Analysis	Yes	No
(b) Organic Analysis	Yes	No
3. PHYSICAL CHEMISTRY	NO	Yes
Practical Exercises	No	Yes
4. PREPARATION OF COMPOUNDS		
(a) Organic	No	Yes
(b) Inorganic	No	Yes

hurriedly read and understand the theoretical background of the experiment they are about to carry out.

It is the writers view that this arrangement is totally unsatisfactory. The two hours per week allocated for practial work as against six hours for theory lessons has been considered earlier on as unsatisfactory. To use part of this laboratory time to give hurried theoretical background is to reduce the period of effective practical work. It is possible to give students reading assignments about the theoretical background well in advanced of a practical lesson. The reading material can be in the form of laboratory manual prepared as it is done in physical chemistry experiments, preparations of inorganic and organic compounds etc. This laboratory manuals must however be given to students well in advance of the laboratory lesson. The reading assignment can then be reinforced by short discussion before the practical work is started.

The present system where students come to the laboratory with only vague ideas of what experiments they are coming to do does not give adequate opportunites for students to understand the principles or logic underlying

the experimental approach. The writer submits that while it is perfectly possible to perform an experiment by following a set of instructions and to do so with no understanding of theory or principle such an activity will not justify the purpose and the investment made in science laboratories.

The importance of pre-laboratory instruction has been pointed out by such psychologists as Ausubel, Novak Gagne etc. Gagne (1967) for example agrees that while enuiry is a vital objective of science instruction two major prerequisites must be incoporated if the practice of enquiry is to be carried out successfully. These prerequisites are:

(1) A suitable background of generalized knowledge which can be used in solving problems to make the inductive leap that characterise enquiry.

(2) The possession of incisive knowledge which makes it possible to discriminate between a good idea and a bad one.

A good pre-laboratory instruction should help students to think about the experiment in terms of the

problem to be investigated, and as a question requiring experimental data. A good pre-laboratory instruction should help students understand the experimental procedure including its limitations, and to stimulate thinking about the observations made during the experiment.

4.5 THE EXPERIMENTAL PHASE IN TITRIMETRIC ANALYSIS.

Table VII gives an analysis of the cognitive and manipulative skills demanded from students in the series of experiments contained in the unit titrimetric analysis. The experiments in the unit provides a wide variety of laboratory experiences from which studenis can develop a wide range of abilities which have been classified using the modified swain's method, in table VIII.

Although the experimental phase provides satistfactory experiences for students to develop most of the abilities contained in the experimental phase of the laboratory work there were serious ommissions in this unit. It is unbelievable to note that throughout an average of

fourteen practical sessions (28 hours) on titrimetric analysis no opportunity was provided for students to prepare solutions for titrations on their own and thus be able to appreciate the need for standardisation of solutions. The weighing practice which is one of the prerequisite skills for preparing solutions was usually carried out in the second year when all exercises on titrimetric analysis have been completed.

TABLE VII:

AN ANALYSIS OF THE COGNITIVE AND MANIPULATIVE SKILLS DEMANDED IN THE EXPERIMENTAL PHASE OF TITRIMETRIC ANALYSIS.

EXPERIMENTAL UNIT	COGNITIVE SKILLS DEMANDED BY EXPERIMENTS.	MANIPULATIVE SKILLS DEMANDED BY EXPERIMENTS.
TITRIMETIC ANALYSIS	(1) Ability to follow and comprehend instruction. (2) Ability to make and record accurate observations.	(1) Ability to select and assemble pieces of apparatus for volumetric analysis. (2) Ability to use Burette and pipette (3) Ability to use indicator.

TABLE VIII:

A CLASSIFICATION OF THE ABILITIES DEMANDED IN THE EXPERIMENTAL PHASE OF TITRIMETRIC ANALYSIS.

PRACTICAL OBJECTIVES	PRACTICAL LESSONS HAD PROVISION FOR ATTAINING PRACTICAL OBJECTIVES.
1. (i) Ability to follow and comprephend written/verbal instructions.	Yes
(ii) Ability to select and assemble and apparatus to perform a standard/novel function.	Yes
2. Manipulation. (i) Ability to use familiar/ unfamiliar apparatus/materials.	Yes
(ii) Ability to implement familiar/unfamiliar procedures.	Yes
3. Observation Ability to make accurate qualitative and quantitative observation	Yes
4. Ability to record accurately the experimental data obtained.	Yes

4.6 THE CONCLUSIONS TO THE EXERPIMENTS IN TITRIMETRIC ANALYSIS.

The type of conclusions required from the exercises in the unit titrimetric analysis are summarised in Table IX. While opportunities are provided for students to arrange/organize/classify data obtained from experiments the interpretation of results and drawing of conclusions are carried out with the teachers assistance. The interpretation of results and drawing of conclusions are usually in the form of chemical calculations in which equations are provided by the teachers. The type of calculations required include:

(i) Calcalate the molarity of solution X

(ii) Calculate the concentration in g/dm^3 of solution X.

(iii) What is the percentage purity of solution X.

(iv) What is the percentage of water of crystallisation in salt X?

Questions testing students understanding of underlying principles of the practical work are absent. One would have expected to see questions on theory of indicators in some of the exercises in this unit, unfortunately no

such questions were asked. Balanced equations were usually provided instead of allowing students to have meaningful practice in writing balanced equations of reaction.

TABLE IX:

AN EVALUATION OF THE TYPE OF CONCLUSIONS DEMANDED FROM STUDENTS IN THE EXPERIMENTS CONTAINED IN THE UNIT TITRIMETRIC ANALYSIS.

PRACTICAL OBJECTIVES	PRACTICAL LESSONS HAD PROVISIONS FOR ATTAINING PRACTICAL OBJECTIVES.
1. Ability to arrange/organise/ classify data obtained in tabular form.	Yes
2. Ability to interpret results and draw conclusions	No
3. Ability to use information obtained from experiment to answer questions on underlying theoretical principles.	No

Perhaps it might be argued that the two hour laboratory sessions per week places great constraints on what can be reaonsably required from students within this period. However the writer feels that the constraint of time need not rob the practical exercise of its educational potential. It has been suggested that the practical work can be divided into three time units:

(i) Pre-laboratory session

(ii) Experimentation

(iii) Post-Laboratory session.

The first and third phases need not take place during the two hour laboratory session. Students may be allowed to make and record all observations in the laboratory and take the data collected home for interpretation and for answering questions related to the underlying principles of the experiment. The latter phase will constitute part of the post-laboratory session.

4.7 THE EXPERIMENT - QUALITATIVE ANALYSIS.

The cognitive and manipulative skills demanded by

the experimental phase of the unit qualitative analysis are summarised in table X. A classification of the abilities identified in Table X using the modified Swain's method is given in table XI. Table XI shows that the experimental phase of the unit qualitative analysis provides satisfactory opportunities for students to develop most of the abilities classified under the experimental phase of laboratory work.

TABLE X:

AN ANALYSIS OF THE COGNITIVE AND MANIPULATIVE SKILLS DEMANDED BY THE EXPERIMENTAL PHASE OF QUALITATIVE ANALYSIS.

EXPERIMENTAL UNIT	COGNITIVE SKILLS DEMANDED BY EXPERIMENTS.	MANIPULATIVE SKILLS DEMANDED BY EXPERIMENTS.
QUALITATIVE ANALYSIS (a) Inorganic (b) Organic	(1) Ability to follow and comprehend instructions. (2) Ability to make and record accurate observations.	(1) Ability to select and handle appropriate glass ware (2) Ability to use spatula, test tube holders. (3) Ability to use the bunsen burner for appropriate heating. (4) Ability to use current reagent bottles. (5) Ability to use filter paper technique for collecting precipitate.

TABLE XI:

A CLASSIFICATION OF THE ABILITIES DEMANDED IN THE EXPERIMENTAL PHASE OF QUALITATIVE ANALYSIS.

PRACTICAL OBJECTIVES	PRACTICAL LESSONS HAD PROVISIONS FOR ATTAINING PRACTICAL OBJECTIVES.
1 (i) Ability to follow and comprehend written/verbal instructions.	Yes
(ii) Ability to select and assemble apparatus to perform a standard/novel function.	Yes
2 Manipulation	
(i) Ability to use familiar/ unfamiliar apparatus/ materials.	Yes
(ii) Ability to implement familiar/unfamiliar procedures.	Yes
3 Observation	
(i) Ability to make accurate qualitative analysis	Yes
4 Recording	
Ability to record accurately the experimental data obtained	Yes

4.8 THE CONCLUSIONS TO THE EXPERIMENTS - QUALITATIVE ANALYSIS.

Table XII gives a summary of the type of conclusions demanded from students in the experiments carried out in the unit qualitative analysis. In most of the exercises in qualitative analysis, the student is encouraged to develop a skill in qualitiative analysis by working his way through successive "unknown salts" selected by the teacher. The activities are useful in developing a deductive frame of mind and provides first-hand knowledge of several basic organic and inorganic reactions. There is however, a major draw back in this approach. There is always a risk that at some point during the series of exercises the work will become routine. Students may then perform mechanically with little understanding of what they are doing and slavishly follow the practical handout containing the scheme for qualitative analysis. This draw back can be overcomed by introducing controlled tests into qualitative analysis. In this approach students are asked to carry out specific chemical

tests not necessarily in the order or sequence found in traditional scheme for qualitative analysis. Students are asked to record their observation and make their inferences from the observations made. This approach will make the student think analytically about what he is doing in order to under stand it and be able to make useful inferences.

TABLE XII:

AN EVALUATION OF THE TYPE OF CONCLUSIONS DEMANDED FROM STUDENTS IN THE EXPERIMENTS CONTAINED IN THE UNIT QUALITATIVE ANALYSIS.

PRACTICAL OBJECTIVE	PRACTICAL LESSONS HAD PROVISIONS FOR ATTRAINING PRACTICAL OBJECTIVES.
1. Ability to arrange/organize/ classify data obtained in tabular form.	Yes
2. Ability to interpret results and drawn conclusions.	Yes
3. Ability to use information obtained from experiment to answer questions on underlying theoretical principles.	No

4.9 THE EXPERIMENT - PHYSICAL CHEMISTRY LABORATORY EXERCISES.

Table XIII gives an analysis of the cognitive and manipulative skills demanded by the experiments contained in the unit physical chemistry experiments. Table XIV is a classification of these skills using modified version of Swain's method. Table XIV shows that the experimental phase of the unit provides adequate opportunities for students to develop most of the abilities classified under this phase of laboratory work.

TABLE XIII: AN ANALYSIS OF THE COGNITIVE AND MANIPULATIVE SKILLS DEMANDED IN THE EXPERIMENTAL PHASE OF SELECTED PHYSICAL CHEMISTRY EXPERIMENTS

EXPERIMENTAL UNIT	COGNITIVE SKILLS DEMANDED BY EXPERIMENT.	MANIPULATIVE SKILLS DEMANDED BY EXPERIMENT.
SELECTED EXPERIMENTS IN PHYSICAL CHEMISTRY e.g. 1. Heat of Reaction 2. Partiition co-efficient 3. Rate of hydrolysis 4. Determination of activitation energy. 5. Depression of Freezing point. 6. Determination of solubility product	(1) Ability to follow and comprehend instruction. (2) Ability to implement familiar and unfamiliar procedures. (3) Ability to make accurate qualitative and quantitative observations.	Ability to use familiar/unfamiliar appratus/materials like. (1) stop clock (2) calorimeter (3) melting point determination apparatus. (4) Electrical balance. (5) Thermometer (6) Separating funnel (7) Measuring cyclinders. (8) Volumetric analysis apparatus.

TABLE XIV: A CLASSIFICATION OF THE ABILITIES DEMANDED IN THE EXPERIMENTAL PHASE OF PHYSICAL CHEMISTRY LABORATORY EXERCISES.

PRACTICAL OBJECTIVE	PRACTICAL LESSONS HAD PROVISIONS FOR ATTAINING PRACTICAL OBJECTIVES.
1 (i) Ability to follow and comprehend written/ verbal instructions.	Yes
(ii) Ability to select and assemble apparatus to perform a standard/ novel function.	Yes
2 Manipulation (i) Ability to use familiar/ unfamiliar apparatus/ materials.	Yes
(ii) Ability to implement familiar/unfamiliar procedures.	Yes
3 Observation. (i) Ability to make accurate qualitative and quantitative observation.	Yes
4 Recording Ability to record accurately the experimental data obtained.	Yes

4.10 THE CONCLUSION TO THE EXPERIMENTS - PHYSICAL CHEMISTRY LABORATORY EXERCISES.

Table XV is a summary of the conclusions demanded from students in the selected experiments in Physical chemistry.

Interpretation of results usually involves chemical calculations for which the teacher provides detailed guidelines. In this approach the teacher does most of the interpretation of experimental results. This robs the students of the opportunity to develop the abilities for interpreting observations, data etc. Very few questions were asked in this unit which test students understanding of underlying theoretical principles.

4.11 THE EXPERIMENT - PREPARATION OF COMPOUNDS.

Table XVI gives a summary of the cognitive and manipulative skills demanded in the experimental phase of the unit preparation, of compounds. A classifications of these skills and abilities is summarised in Table XVII.

The unit provides opportunities for students to develop most of the abilities classified under experimental phase of laboratory work. The unit also provides opportunities for first hand experience in preparation of compounds

TABLE XV:

AN EVALUATION OF THE TYPE OF CONCLUSIONS DEMANDED FROM STUDENTS IN THE EXPERIMENTS CONTAINED IN THE UNIT PHYSICAL CHEMISTRY LABORATORY EXERCISES.

PRACTICAL OBJECTIVE	PRACTICAL LESSONS HAD PROVISION FOR ATTAINING PRACTICAL OBJECTIVES.
1. Ability to arrange/organize/ classify data obtained is tabular/graphical form.	Yes
2. Ability to interpret results and draw conclusion.	No
3. Ability to use information obtained from experiment to answer questions on underlying theoretical principles.	No

TABLE XVI:

AN ANALYSIS OF THE COGNITIVE AND MANIPULATIVE SKILLS DEMANDED BY LABORATORY EXERCISES ON PREPARATION OF CHEMICAL COMPOUNDS.

EXPERIMENTAL UNIT	COGNITIVE SKILLS DEMANDED BY EXPERIMENTS.	MANIPULATIVE SKILLS DEMANDED BY EXPERIMENTS.
PREPARATION OF CHEMICAL COMPOUNDS (a) ORGANIC (i) Acetanilide (ii) Benzanilide. (b) INORGANIC (i) Copper (II) ammonium sulphate hexahydrate (ii) Tetrammine Copper (II) sulphate monohydrate.	(1) Ability to follow and comprehend instructions (2) Ability to implement familiar and unfamiliar procedures.	(1) Ability to manipulate familiar/unfamiliar apparatus/materials like: (1) 'quick fit' refluxing kit (2) filtering pump (3) melting point determination apparatus.

TABLE XVII:

A CLASSIFICATION OF THE ABILITIES DEMANDED BY THE EXPERIMENTAL PHASE OF THE UNIT - PREPARATION OF COMPOUNDS.

PRACTICAL OBJECTIVE	PRACTICAL LESSONS HAD PROVISIONS FOR ATTAINING PRACTICAL OBJECTIVES.
1 (i) Ability to follow and comprehend written/verbal instructions.	Yes
(ii) Ability to select and assemble apparatus to perform a standard/novel function.	Yes
2. Manipulation (i) ability to use familiar/ unfamiliar apparatus materials	Yes
(ii) ability to implement familiar/ unfamiliar procedure.	Yes
3. Observation Ability to make qualitative observation.	Yes
4. Recording Ability to record accurately the experimental data obtained	Yes

The number of exercises in the unit is however small- only two.

4.12 CONCLUSIONS TO THE EXPERIMENTS PREPARATION OF COMPOUNDS.

The conclusion demanded from preparation of compounds is usually in the form of producing high purity compounds as indicated by melting point/ boiling point determination.

In the experiments on preparation of compounds the production of the compound was all that was required. Degree of purity together with melting point determinations were not emphasised.

4.13 SUMMARY OF MAJOR FINDINGS.

The three phases to an experiment was evaluated for all the experimental units. The study showed that there was no satisfactory provision to ensure that students acquire adequate theoretical background for the practical work. The experimental unit - qualitative analysis was however an exception - It had fairly

adequate provisions for pre-laboratory instruction.

The study revealed that the experiment phase of laboratory work provided satisfactory range of experiences from which students can develop a vairety of desirable abilities. There were however few omissions and suggestions have been made under appropriate units.

The conclusions to the experiments was found to be generally weak in all the experimental units. The interpretation of results were largely assisted by teachers and there were not many questions designed to test students' understanding of principles of the experiment.

CHAPTER V

5.1 SUMMARY AND GENERALISATIONS.

This study was carried out to evaluate the nature and mbjectives of chemistry practical lessons at the Katsina College of Arts Science and Technology Zaria. In evaluating the nature of the Chemistry Practical lessons an assumption was made that the nature of most of the chemistry practical lessons encountered can be can be fitted in a continuum with the traditional approach at one end and the modern investigatory approach at the other end. In the traditional approach, the teacher selects experiments, describes which data are to be collected and evaluates the data. Detailed instructions are usually provided. On the other hand in the modern investigatory approach, the student selects experiment, decides which data to collect and evaluates data. Teacher direction is usually minimal.

In evaluating the nature of chemistry practical lessons, the laboratory exercises carried out in the chemistry practical course were classified into

experimental units. Each experimental unit was defined in terms of the cognitive and manipulative skills required in carrying out the laboratory exercise. The nature of each experimental unit was evaluated using the following variables as yardstick.

1. Time allocation to theory and practical lessons.
2. The relationship between what was learnt in theory and what was done in practical lessons.
3. The responsibilty for designing the procedure or technique for carrying out laboratory exercises - teachers' or students'?
4. Treatment or interpretation of data-students' responsibility or teacher gives full guidance?

The study has shown that there was very little correlation between theory and practical lessons in chemistry at the college. The symbiotic relation that should exist between theory and practical lessons is absent and chemistry practical lessons appear to be a mere illustrative appendage of the course theory. This observation is further supported by the disproprostionate time allocation of two hours for practical lessons per

week as against six hours for theory lessons per week.

The nature of the practical lessons was found to be basically traditional with the teacher deciding the design of the experiment and the teacher giving detailed guideline on what data to collect and in many cases the teacher helps the student to interprete data. In this approach to practical work only the teacher is engaged in the investigatory processes of science and students are denied the opportunities for developing intuitive mode of thinking which is vital for creativity.

The objectives of chemistry practical lessons were evaluated using a modified version of Swain's model. Each experimental unit was annalysed to find out whether it provided experiences that can enable students develop a wide variety of abilities classified under the three phases to an experiment viz.

(i) the road to the experiment

(ii) the experiment

(iii) the conclusion to the experiment.

The study showed that except for the experimental unit on qualitative analysis the other experimental

units provided no satisfactory theoretical background for practical lessons. Without adequate theoretical background to the practical work, students will not be able to appreciate the logic behind experimental procedures, including its limitations. The road to the experiment is a phase of laboratory work that has great potentials for developing in students the spirit of 'fluid enquiry' which is vital for intuitive thinking and creativity. When this phase of laboratory work is weak, practical work is reduced to mere 'cook book' practise, where students perform experiment by following a set of instructions with no understanding of theory or principle. At best such an approach can produce efficient technicians good at servicing imported technology but poor in creativity and incapable of developing local technology. This is the very opposite of Nigeria's goals for science education. Such an output will not justify the

against theory.

The conclusion to an experiment is found in the interpretation of data and it is this interpretation that generates new questions, stimulates further inquiry helps to solve problems and leads to possible refinement of theories.

5.2 Limitations

The findings in this study are applicable to the conduct of chemistry practicals at the Katsina College of Arts Science and Technology Zaria. The college is one of the oldest colleges offering courses in I.J.M.B. The results of the college in chemistry has consistently been one of the best quantitatively and qualitatively since the inception of the I.J.M.B. examinations. Many of the newer colleges of arts and sciences have copied most of the administrative and academic set up of the college. The findings of this study can therefore give a fair indication of what is to be expected in other institutions offering I.J.M.B. courses in chemistry.

The findings of the study cannot be generalised

for all science subjects in the college. Each subject has its peculiarities and the nature and objectives of practical work is likely to be affected by the peculiar nature of the other science subjects.

5.3 Recommendations

Venkatachelam and Rudolph (1974) have proposed a useful model to serve as guide when innovation and improvement of existing laboratories programmes are contemplated. The model titled "The Paradign of educational requirements" proposed that any contemplated innovation or improvement of laboratory programme must be preceeded by a precise definition of educational objectives. The constraints of the system are then identified and taken into account when the desired programme is to be designed. The model defined success criteria for any proposed innovation or improvement of programme in terms of its feasibility and its effectiveness.

Educational objectives of science practical lessons are of two types - general statements and objectives defined in specific operational terms.

Previous studies (Kerr, West, Johnstone and Wood etc.) have given a list of general statements of objectives of chemistry practical lessons which were highly rated by chemistry teachers. Some of these general statements include:

(1) To arouse and maintain interest in the subject

(2). To promote simple common sense scientific methods of thought.

(3) To be an integral part of the process of finding facts by investigation and arriving at principles.

(4) To elucidate the theoretical work so as to aid comprehension.

(5) To encourage accurate observation and careful recording.

(6) To learn some basic laboratory skills and techniques.

(7) Given an experimental problem to be able to recognise the pieces of data that must be collected to solve that problem.

Swain's comprehensive list of practical objectives provides a detailed classification of objectives defined in specific operational terms.

The general statements of objectives given above together with the modified version of Swain's model of practical objectives defined in specific operational terms provides a useful guide in the selection of objectives of chemistry practical lessons in the college.

Some of the constraints of the system have already been identified in the earlier part of this work. They include.

1. Increasing enrollments leading to over-crowding of laboratory space.
2. Logistics
3. Specification of the chemistry practical syllabus.
4. Instructor time.

Considering the desirable educational objectives of practical lessons on one hand and taking into account the constraint of the system on the other hand the following recommendations are considered feasible and are deemed effective in enhancing the educational potential of chemistry practical lessons.

1. There is need for a reorganisation of practical and theory schedules so that the symbiotic relationship between theory and practical work is established. There is no reason why selected experiments illustrating certain principles of physical chemistry cannot be conducted at the time students are learning the relevant theory component. Qualitative inorganic analysis are better appreciated after the student has been given good grounding on ionic equilibria especially the concept of solubility product. In some cases where it is difficult to arrange relevant theory work to go along side practical work, extensive theoretical background can be provided in a handout. The handout must be given in advance of the practical lesson. In acid base titration, a preliminary theoretical background on concepts of acids and bases together with the theory of indicators can be prepared in a handout preceeding laboratory exercise on volumetric analysis. There is need for high correlation between what was learnt in theory lesson and what was done in the laboratory.

2. There is need for reappraisal of the approach to chemistry practical lessons. Three phases to a laboratory work have been identified - pre-laboratory, experiment and post laboratory. Each of these phases to the laboratory is unique in developing certain abilities in the student. Each of the phases must be provided for. Past practices have tended to emphasise the experimental phase and teachers have tended to usurp students role in the pre-laboratory and post-laboratory phases of the experiment. The writer does not condemn the practice of giving guidance to students. What the writer objects to is a situation where all the pre-laboratory phase of the experiment are prepared in details by teachers leaving very little or no opportunity for students to develop creative mind and the situation where the teacher does most of the interpretation of experimental observations and data without allowing students to develop problem solving skills. There is a need to strike a balance between leaving students to the whole practical problem in chemistry and Spoon feeding students on how to solve problems in chemistry. Neither of the extremes is

desirable.

3. There is need to make chemistry practical lessons exicting and dynamic. The lesson should foster a sense of wonder. Generally when new students are enrolled into the science department they look forward to a laboratory class with pleasant anticipation. This initial enthusiasm can be killed if laboratory work becomes a bore because of excessively rigid formality, unexciting exercises or 'cook book' techniques.

The exciting laboratory lesson is one in which a suitable frame of mind has been created in the student about the problem to be investigated. The problem investigated must appear real and worthy of study. The student should have some knowledge of the possible methods for solving the problem and the student should achieve a sense of accomplishment on completion of the work.

4. There is need to re-organise chemistry practical lessons so that it can foster creative attitudes in students. Students should participate if possible in

defining the problem and the method of solving it as well as in drawing final conclusions. This can be achieved in a number of ways. One way is to give brief theoretical background and procedure of the practical work in a handout. The handout should include selected references from which students are expected to find more information on the theoretical background to the study, the logic and limitations of experimental procedure to be used.
Questions on these aspects are then asked to ensure that students understood the purpose and procedure of the experiment. Another way of achieving the same objectives is to reserve at least one practical session in each of the experimental units for novel experiments. In such a laboratory session students are given a problem to solve with minimal directions. The problem must be related to the other problems investigated in the particular experimental unit. The student is then called upon to design his own experiment collect his own data and interprete the data to solve the problem investigated. This approach corresponds to the 'challenge cycle' in Venkatachelam and Rudolph's study.

5. There is need to have a marking scheme constructed on the basis of skills and abilities the practical lesson is out to test. This is essential because the objectives of any course are unlikely to be achieved unless in addition to being well understood by the teachers they are fully reflected in his methods of assessment. At present no marking schemes were prepared for weekly assessment of chemistry practical lessons, and this despite the fact that there are nine different groups each in Year I and Year II. Because of the absence of marking schemes, teachers have adopted varying methods of assessment varying from alphabetical grading to percentage grading without clear yardstick for arriving at such assessment.

5.4 AREAS FOR FURTHER INVESTIGATION.

1. There is need for an investigation of this nature on a wider scope to incoporate all the thirteen colleges offering I.J.M.B. courses. The results of such an investigation will give a more comprehensive view of the nature and objectives of chemistry practical lessons in the I.J.M.B. course.

Such an investigation will provide useful feedback to the organisers of I.J.M.B. courses to see possible areas of improvement.

2. There is need for a research into the effect of the prescribed chemistry practical syllabus on the role of practical lessons vis a vis the ry lessons. Such a study will throw light on the desirability or otherwise of the present chemistry practical syllabus.

3. There is need for research on ways of providing meaningful practical work for each theoretical principle learnt. Chemistry is an experimental subject but teachers often find it difficult to arrange meaningful and feasible practical lessons on many abstract theoretical concepts such as:

1. Gross featuresof the atom.
2. Chemical bonding
3. Gas laws
4. Many topics in inorganic chemistry
5. Many topics in organic chemistry.
6. Nuclear chemistry.

Such a study will help to promote the symbiotic relation between theory and practical lessons.

4. There is need for a similar evaluation of the nature and objectives of practical lessons in other science subjects mainly Physics and Biology. Such a study will reveal areas of strength in the approaches used and area of weaknesses requiring improvement .

BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

1. Adaralegbe A. (ed) A Philosophy for Nigerian Education Proceedings of N.C.C. 8-12 1969.

2. Alabi T.O. An Evaluation of the Organisation of Science Laboratories at the Katsina College of Arts Science and Technology Zaria unpublished M.Ed. Term Paper A.B.U. Zaria, 1977.

3. Allison H.T. A modern Approach to WASC practical Chemistry Examination: Journal of STAN Vol.15 No.3 August 1977.

4. Bruner J.S. The Process of Education. New York Alfred & Knopf Inc. 1960.

5. Gagne R.M. The learning requirements for enquiry Section 7 page 410 in Readings in Science Education. The Macmillan Company 1967 p.410.

6. Joint Matriculation Board (JMB) Internal assessment of Practical skills in Chemistry (Advanced): Notes for the guidance of Teachers J.M.B. Publication March, 1974.

7. Johnstone and Wood: Practical work in its own right: Education in Chemistry Vol.14 No.1 1977.

8. Kerr J.F. Practical work in School Science: Letcester University Press, 1964.

9. Lippincott W.T. The Instructional Laboratory: Purposes and Organisation. Journal of Chemical Education Vol.52 No.1 Jan. 1975 page 29.

10. Mager R. Preparing Instructional Objectives. Fearon 1962 p.vii.

11. Mathewson J.H. Student Laboratories: An under-developed Educational Resource: Science Education Vol.51 No.2 March, 1967.

12. Odhiambo T.R. Understanding of Science: The impact of the African view of Nature page 39. in Science Education in African edited by Gilbert and Lovegrove Heinmann Education Books Ltd. 1972.

13. Schwab J.J. The Teaching of Science as enquiry in the teaching of science Haward University Press 1962.

14. STAN Editorial opinion. Examination Journal of S.T.A.N. Vol.13 No.2 April 1975.

15. Swain J.R.L. Practical Objectives - a review Education in Chemistry Vol.II No.5 Sept. 1974.

16. Venkatachelam and Rudolph: Cook Book versus Creative Chemistry - A New Approach to Research Oriented General Chemistry Laboratory Journal of Chemical Education Vol.51 No.7 July 1974 p.479.

17. Watson G. What Psychology can we feel sure about? Educational digest May 1960.

18. West R.W. Objectives for Practical Work in School Chemistry School Science Review Vol.54. No.186 1972.

19. Whitfield and Eggleston: Practical Work in School Chemistry Unpublished UNESCO Report 1968.

APPENDIX A

A Sample of practical exercises on the experimental unit titrimetric analysis.

EXPERIMENTS CARRIED OUT UNDER THE EXPERIMENTAL UNIT TITRIMETRIC ANALYSIS

1. Standardisation of NaOH using standarised H_2SO_4
2. Standardisation of H_2SO_4 with standard Na_2CO_3.
3. Determination of percentage purity of oxalic acid using standard NaOH solution.
4. Determination of percentage composition of a mixture of solution containing X% NaOH and Y% Na_2CO_3 using standard HCl solution. Indicators phenolphthalein and methyl organge.
5. Determination of percentage compositionof a solution containing a mixture of Na_2CO_3 and $NaHCO_3$ using standard HCl. Indicators phenolphthalein and Methyl orange.
6. Standardisation of $KMnO_4$ using 0.05M oxalic acid.
7. To standardise a given solution of Ferrous ammonium solphate using 0.02M $KMnO_4$.
8. Standardisation of $Na_2S_2O_3$ using 0.02M $KMnO_4$
9. Standarisation of $Na_2S_2O_3$ using KIO_3
10. To determine the number of moles of water crystallisation in $CuSO_4.X\,H_2O$.

11. To determine the percentage purity of sample of impure $CuSO_4 \cdot 5H_2O$.
12. To determine the percentage purity of $FeSO_4 (NH_4)_2 SO_4 \cdot 6H_2O$ in a given solution.
13. To determine the percentage of a mixture of the solution containing X% oxalic acid and Y% sodium oxalate.

EXERCISES ON TITRIMETRIC ANALYSIS

EXPERIMENT: To standardise a solution of sulphuric acid.

'A' is a solution of sulphuric acid of unknown concentrations.

'B' is a solution of Na_2CO_3 containing 5.30g of the anhydrous substance in 1 dm^3 of the solution.

Put acid in the burette and titrate against 25,00 cm^3 of the carbonate solution 'B' using methyl orange as indicator. From your results calculate

(a) the molarity of the acid

(b) concentration of the acid in 1 dm^3 of the solution.

Equation of reaction.

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

EXPERIMENT: To determine the amounts of Na_2CO_3 and $NaHCO_3$ in a given solution by titrating it against standard H_2SO_4 0.05M.

Solution 'A' is 0.05M H_2SO_4. Solution 'D' is a mixture of Na_2CO_3 and $NaHCO_3$. Put solution 'A' into the burette and titrate against 25.00 cm^3 of solution D using first phenolphthalein indicator. Record the burette reading when phenolphthalein colour fades. Add two drops of methyl orange to the solution in the conical flask and continue the titration until the methyl orange indicator changes colour. Record your burette reading at this point also.

N.B.

(1) Reaction when phenolphthalein indicator is used.

$Na_2CO_3 + H_2SO_4 \longrightarrow NaHCO_3 + NaHSO_4$.

Suppose this volume of H_2SO_4 = X Cm^3

i.e. only half of Na_2CO_3 is neutralised

$\therefore$ Volume of $H_2SO_4 \equiv Na_2CO_3$ = 2X cm^3.

(ii) Reaction when methyl orange is used

$NaHCO_3 + NaHCO_3 + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

(Derived from Na_2CO_3) (Present in the mixture)

i.e. When methyl orange is used both $NaHCO_3$ derived from Na_2CO_3 and $NaHCO_3$ present in the solution are neutralised. Suppose this volume of $H_2SO_4 = Y cm^3$

$\therefore$ Volume of $H_2SO_4 \equiv NaHCO_3 = (Y-X)\ cm^3$ (present in the mixture)

Calculations

Calculate the molarity and concentration in g/dm^3 of Na_2CO_3 and $NaHCO_3$.

(i) For Na_2CO_3

$$\frac{M_a V_a}{1} \text{ (acid)} = \frac{M_b V_b}{1} \text{ (base)}$$

(ii) For $NaHCO_3$

$$\frac{M_a V_a}{1} \text{ (acid)} = \frac{M_b V_b}{2} \text{ (base)}$$

EXPERIMENT: DOUBLE REDOX TITRATION

You have been provided with the following solutions.

1. Solution A is 0.1M iron II ammonium sulphate
   ($FeSO_4 - (NH_4)_2 SO_4 6H_2O$)
2. Solution B is $KMnO_4$
3. Solution C is Oxalic acid. It contains 6.3g of the hydrated sult in 1000 cm^3.
4. Solution D is dilute H_2SO_4

PROCEDURE

FIRST TITRATION

Take 25 cm^3 of solution A in a conical flask and add about 5cm^3 of dilute H_2SO_4. Titrate this mixture with solution B until a pink colour just appears. Carry out at least two accurate titrations. Record your readings and from these calculate the molarity of solution B equation of reaction.

$$5\ Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow Fe^{3+} + Mn^{2+} + 4H_2O$$

$$\frac{M_F V_F}{M_p\ Vt} = \frac{5}{1}$$

f = iron II

P = permangande.

SECOND TITRATION

Take 25 cm^3 of solution C in a conical flask.and add 10cm^3 of dilute H_2SO_4. Heat the mixture until it starts to boil then titrate with the standardised $KMnO_4$ solution B supplied. Carry out at least two accurate titrations and record your readings. From these calculate:

(1) The molarity of oxalic acid solution.

(2) The percentage of water of crystallisation in oxalic acid.

(Molar mass of hydrated oxalic acid $H_2C_2O_4 \cdot XH_2O$ = 126).

Equation of reaction.

$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

EXPERIMENT: Standardisation of sodium this sulphate solution using solutions of $KMnO_4$ and standard oxalic acid.

You are provided with the following

Solution A - Potassium Permanganate

Solution B - Sodium thiosulphate

Solution C - Potassium Iodide

Solution D - Dislute H_2SO_4

Solution E - Oxalic acid

Indicator - .05M Freshly Prepared starch solution

First titration

Determine the molarity of $KMnO_4$ by tirating against standard oxalic acid (.05M). $25cm^3$ of solution is taken in a conical flask, $10cm^3$ of dil H_2SO_4 is added and the mixture is heated before titration with solution A.

Equation of reaction

$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

Second titration

Take 25 cm^3 of solution A in a conical faask, and add 10CM^3 each of solutions C and D a deep brown colour appears. Titrate this mixture with solution B from the burette till a pale yellow colour is obtained. Add few drops of freshly prepared starch solution and titrate till the blue colour disappears equation of reaction.

$$2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \longrightarrow$$
$$2Mn^{2+} + 55 + O_6^{2-} + 8H_2O$$

EXPERIMENT. DOUBLE REDOX TITRATION

Solution A contains 1.6g/dm^3 of $KMnO_4$

Solution B is sodium thiosulphate

Solution C is a solution of hydrated copper sulphate.

Solution D is Potasium Iodide.

Solution E is Dilute H_2SO_4

Using solution 'A' standardise solution 'B' and then using '[illegible]' find

(a) molarity of solution C

(b) concentration of C in g/dm^3

PROCEDURE

FIRST TITRATION

Take 25cm^3 of standard $KMnO_4$ solution in a conical flask add 10cm^3 of dil. H_2SO_4 and another 10cm^3 of Potassium Iodide solution. A deep brown colour appears. Titrate the contents of the conical flask with sodium thiosulphate solution from the burette till the colour changes to fale yellow. At this stage add few drops of starch solution and continue titrating with sodium thiosulphate until the blue colour fades.

Equation of reaction

$$2MnO_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

$$5I_2 + 10\ S_2O_3^{2-} \longrightarrow 5\ S_4O_6^{2-} + 10I^-$$

$$2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \longrightarrow 2Mn^{2+} + 5S_4O_6^{2-} + 8H_2O$$

$$\frac{M_k\ V_k}{2} = \frac{M_T\ V_T}{10}$$

Second Titration

Take $25cm^3$ of $CuSO_4 \cdot 5H_2O$ Solution is a conical flask and add $10CM^3$ of KI solution. A yellowsih brown precipitate is formed. Titrate with $Na_2S_2O_3$ solution from the burette till the colour of the precipitate changes to pale yellow. Then add few drops fresh starch solution as indicator, and continue titrating with $N_{a2}S_2O_3$ solution till a white precipitate just appears. (i.e. blue colour of the precipitate changes to white).

Equation of reaction:

$$2\ Cu^{2+} + 2I^- \longrightarrow 2\ Cu^+ + I_2$$

$$I_2 + 2\ S_2O_3^{2-} \longrightarrow 2\ Cu^+ + 2\ S_4O_6^{2-}$$

$$2\ Cu^{2+} + 2\ S_2O_3^{2-} \longrightarrow Cu^+ + 2\ S_4O_6^{2}$$

APPENDIX B

A SAMPLE OF PRACTICAL EXERCISES ON THE EXPERIMENTAL UNIT - PHYSICAL CHEMISTRY EXPERIMENTS.

LIST OF EXPERIMENTS IN PHYSICAL CHEMISTRY.

1. Heat of Neutralization of a strong by a strong Basic.
2. Determination of the rate of Hydrolysis of methyl acetate.
3. Depression of freezing point in Binary mixtures (Rast's method)
4. Rate of raction.
   $KMnO_4 + C_2O_4^{2-} \cdots + 16H^+$
5. Determination of activation energy.
6. Determination of the partition coefficient of Iodine between water and carbon tetrachloride.
7. Partition coefficient of Benzore acid between Benzene and water
8. The concept of chemical equilibrium and demonstration of the common ion effect.
9. Determination of the solubility product of calcium dioxide

HEAT OF NEUTRALIZATION OF A STRONG ACID BY A STRONG BASE

(HCl x NaOH)

Strong acids and strong bases are fully ionised in dilute solutions. The salts produced during neutralization are also fully ionised. Therefore the essential reaction involved in the neutralization of any strong acid by any strong base is the union of a hydronium ion and a hydroxyl ion to form water, since other ions remain unchanged. Thus the reaction.

$$H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O$$

may be represented by the general equation

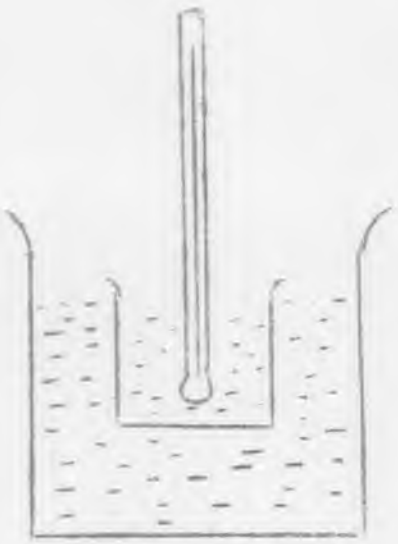
$$H^+ + OH^- \longrightarrow H_2O$$

(The hydrogen ion normally exists in the hydrated form, H_3O^+)

EXPERIMENT

(i) Determination of the thermal capacity of the calorimeter (100 cm^3 glass beaker)

Using a measuring cylinder, pour 50 cm^3 of water at room temperature



into a 100 cm^3 glass beaker and keep the beaker in the outer jacket containing lagging, Stir the water with a thermometer (CARE!) and note the temperature, t_1^oC of the system, to the nearest tenth of a degree. Measure another 50 cm^3 of water and pour into a 250 cm^3 beaker. Heat this water with constant stirring until it is about 20°C above the room temperature. Remove the beaker from the heat and stir the water for a further one minute to ensure homogeneity. Note the temperature t_2^oC and immediately pour the warm water, all at once, into the cold water in the calorimeter. Start a stop clock immediately and stir the content of the calorimeter with the thermometer and note the temperature at half minute intervals until a steady value has been observed for four readings. Plot a graph of temperature against time. Extrapolate the straight portion the graph to zero minute to find the resultant temperature, t_3^oC. Using the equation heat lost = heat gained, calculate the thermal capacity of the beaker.

density of water = 1.000 kg m^{-3} or 1.00 gm cm^{-3}

Specific heat capacity of water = 4 200 J kg^{-1} K^{-1}

(4.20 J g^{-1} K^{-1})

Calculation

Heat lost by warm water = heat gained by calorimeter + cold water

Heat lost warm water = mass x sp. heat capacity x fall in temp.

= 0.05 kg x 4200 j kg^{-1} K^{-1} x $(t_2 - t_3)$

Heat gained by cold water = 0.05 x 4200 x $(t_3 - t_1)$

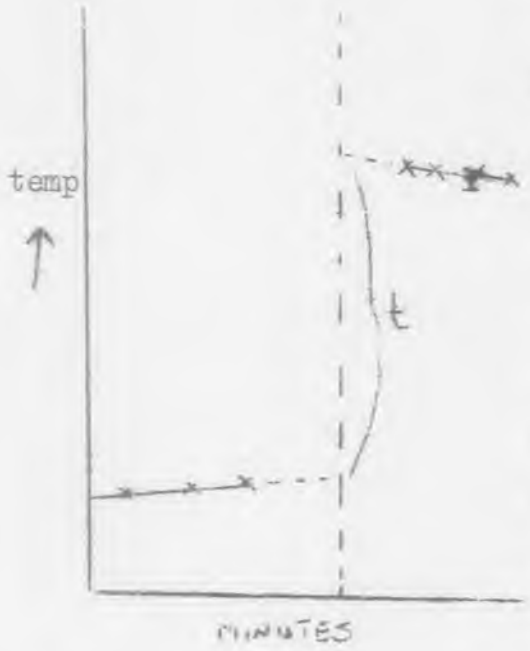
Heat gained by calorimeter = ms $(t_3 - t_1)$

0.05 x 4200 x (t_2-t_3) = 0.05 x 4200 x (t_3-t_1) + ms (t_3-t_1)

(ms is the thermal capacity of the calorimeter)

(ii) Neutralization

Clean and dry the calorimeter. Pour into it 50 cm^3 of the standard sodium hydroxide (1.10M) solution supplied. Take 50 cm^3 of standard hydrochloric acid (1.00M) in a measuring cyclinder. (The molarity of NaOH is slightly higher, so that a definite quantity of acid will have been neutralized). Insert thermometers with 0.1 gradation into each liquid, start a step watch and note the temperatures of the liquids at regular intervals of half minute for five minutes. At the sixth minute pour acid, all at once, to the alkali in the calorimeter and stir the mixture with the thermometer. Note the temperature at the seventh minute and at intervals for several minutes.



Plot a graph of temperature against time. Extrapolate both straight portions of the graph to the sixth minute; the separation of the lines at the sixth minute corresponds to a correct temperature change for the experiment. The extrapolation method compensates for heat gain or loss from the surroundings. Let the temperature change from the graph be 't'.

Calculation

The heat given out during neutralization is taken by both the calorimeter and the mixture (salt solution). The density and the specific heat capacity of the mixture could be taken as those of water.

heat gained by the calorimeter = thermal capacity x t
= ms x t

heat gained by the mixture = mass x sp.heat x t
= 0.10 x 4200 x t

total heat liberated during neutralization = ms x t + 0.10 x 4200 x t
= let the heat be q J

HEAT OF NEUTRALIZATION IS DEFINED AS THE HEAT EVOLVED IN THE REACTION BETWEEN THAT MASS OF AN ACID WHICH FURNISHES ONE MOLE OF HYDRONIUM ION AND THAT MASS OF AN ALKALI WHICH PROVIDES ONE MOLE OF HYDROXYL ION.

Since q J was the heat evolved when 50 cm^3 of 1.0 M acid reacted with 50 cm^3 of 1.0 m base, the heat of neutralization will be

$$\frac{q \times 1000}{50} = 20\ q\ J.$$

DETERMINATION OF THE RATE OF HYDROLYSIS OF METHYL ACETATE

1. THEORY

The speed of a chemical reaction may depend on many factors. Among the most important are:-

The concentration of the reactants.

The temperature,

The presence of a catalyst.

This is an experiment to determine the rate at which methyl acetate is hydrolysed to acetic acid and methyl alcohol.

$$CH_3COOCH_3 + H_2O \rightleftharpoons CH_3COOH + CH_3OH$$

The reaction is very slow but is catalysed by strong acids which provide additional hydrogen ions. The rate of the reaction is increased by the hydrogen ions, but these are not used up during the reaction.

$$HC_3COOCH_3 + H_3O^+ \rightleftharpoons CH_3COOH + CH_3OH + H^+$$

The rate of the reaction will depend on the concentration of the hydrogen ions supplied by the strong mineral acid, as well as on the concentration of the methyl acetate.

In this experiment the temperature is kept constant by immersing the flasks in a sink of running tap water. The rate of reaction is measured by determining the amount of acetic acid formed in a given time.

2. EXPERIMENT

You are provided with:

(a) four 250 cm^3 conical flasks, numbered I, II, III, Iv and each fitted with a cork;

(b) a sample of methyl acetate, labelled A;

(c) standard hydrochloric acid, 1.0M labelled B;

(d) sodium hydroxide solution, labelled C.

(i) Measure the hydrochloric acid into the flasks using a pipette:

10cm^3 each into flasks I, II

20 cm^3 each into flasks III, IV.

(ii) Using a burette measure out 48cm^3, 46cm^3 38cm^3 and 36cm^3 of distilled water into flasks I, II III, & IV respectively.

(iii) By means of a burette introduce methyl acetate into the flasks as follows:

Add 2cm^3 of methyl acetate into flask I. Five minutes later add 4cm^8 methyl acetate to flask II; after interval of five minutes, add 2cm^3 of methyl acetate to flask III, and five minutes after this, add 4cm^3 of methyl acetate to flask IV. Replace the cork to each flask after the addition of the acetate, and shake the contents very well. Then stand all the flasks in a trough of cold water for 40 minutes.

Solution	I	II	III	IV
hydrochloric acid (cm^3)	10	10	20	20
Distilled water (cm^3)	48	46	38	36
Methyl acetate (cm^3)	2	4	2	4
	-	-	-	-
Total volume (cm^3)	60	60	60	60

3. While waiting in (2), standardise solution C against the standard hydrochloric acid solution provided. Use a $25cm^3$ portion of solution B for each titration and phenol phathalein as the indicator. Titrate B against C taken in the burette. Appearance of a faint pink colouration is the end point.

4. After the flask in (2) have been kept standing in the trough of cold water for 40 minutes, take the temperature of the water and record it. Then titrate the contents of flask I against the standardised sodium hydroxide solution. Then at intervals of five minutes, titrate the contents of flasks II, III, and IV. Use phenolphathalein as the indicator in all titrations and take as the end point the appearance of a faint pink colour which persists after shaking for 10 seconds.

Tabulate your results, and from these show how the rate of hydrolysis is related to the concentration of the hydrochloric acid and of the methyl acetate.

CALCULATION

EXAMPLE

Standardisation of caustic soda

25^{cm^3} of HCl $\equiv$ 26.2^{cm^3} NaOH

Final titration figure for Flask I = 14.30^{cm^3} NaOH

In Flask I originally there were 10^{cm^3} HCl, but

$$10^{cm^3} \text{ HCl} \equiv \frac{26.2 \times 10}{25} = 10.48 \text{ cm}^3$$

∴ Volume of NaOH equivalent to the acetic acid produced in Flask I = 14.30 - 10.48 = 3.82 cm^3 NaOH

Since the results of each flask are to be compared, there is no need to convert the volume of caustic soda neutralised into equivalents of acetic acid produced because these are directly proportional to one another. Therefore calculate the volume of caustic soda neutralised by the acetic acid in each flask, remembering that Flasks III and IV contained $20cm^3$ of HCl, and tabulate the results as follows:-

FLASK	Volume of ester cm^3	Volume of HCl	Volume of NaOH required for acetic acid cm^3
I	2	10	3.82
II	4	10	6.87
III	2	20	6.95
IV	4	20	12.60

Comparison of the results for Flasks I and II and of the results for Flasks III and IV indicate the effect of varying the ester concentration on the rate of the reaction.

Comparison of the results for Flasks I and II and of the results for Flasks II and IV will indicate the effect of varying the hydrochloric acid concentration on the rate of the reaction.

DEPRESSION OF FREEZING POINT IN BINARY MIXTURES (RAST'S METHOD)

The freezing point of a substance is generally lowered by the presence of a foreign substance. The lowering of the freezing point is proportional to the concentration of the dissolved substance. From Raoult's law it follows that equimolar weights of substances dissolved in the same weight of a solvent depress its freezing point by the same amount. The depression of freezing point produced by one mole of the solute dissolved in 1 000 g of a solvent is known as molal freezing point depression constant.

$$\Delta T = \frac{1\ 000\ K\ w}{M\ W}$$

(Δ T = depression in fr pt; K = molal f. pt. depression constant)

(W = mass of the solute; M = molar mass of the solute;)

(W = mass of the solvent).

Rast's method makes use of the fact that comphor has a very high molal depression, viz 40°C. - In this case the depression is so great that an ordinary thermometer may be used for the determination of the freezing point.

PROCEDURE:- Weigh accurately an ignition tube; add roughly 0.05 g of the solute and reweigh accurately. Now add roughly 0.5 comphor and pack it well down the tube; weigh accurately again. Plug the mouth of the test tube with cotton wool.

Heat an oil bath to 200°C, then dip the ignition tube. When the mixture is molten, shake to mix well. Remove from the oil bath, wipe off oil and chill at once in cold water the hot period should be brief to avoid sublimation of comphor, and the chilling rapid to avoid separation of the components on crystallization.

Dig out the mixture and grind in a glass mortar. Fill a melting point capillary tube with a 1 cm length sample and seal the tube above the sample. Determine the melting point which is when the last crystal disappears.

Also determine the melting point of pure comphor by the standard procedure.

From the depression observed, calculate the molar mass of the given sample.

Rate of Reaction

Permanganate and oxalate react in an acid medium according to the equation

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Since the products formed in this reaction are colourless, the rate of discharge of the purple colour of permanganate ions can be used as a measure of the rate of the reaction. If in the initial reaction mixture there is only a small quantity of the permanganate, it is consumed completely and the solution becomes colourless in a short time. The faster the initial rate of reaction the shorter the time taken for the solution to become colourless. The initial rate of oxidation is therefore proportional to the reciprocal of the time taken for the purple colour to disappear.

A is 0.0005M potassium permanganate solution. B contains 0.5 mole of oxalic acid per litre of 0.5M sulphuric acid. C was obtained by mixing appropriate quantities of A and B and allowing the reaction to go to completion.

(a) (i) Using 10 cm^3 measuring cylinder, measure 5cm^3 of A into a boiling tube.

(ii) With the other measuring cylinder, measure out 25cm^3 of B, quickly add it to the 5cm^3 of A, and at the same time start the stopclock or stopwatch. Swirl the tube to mix the solutions and leave it to

stand in a beaker or a suitable rack. Place beside this tube another boiling tube containing 30 cc of C and leave a sheet of white paper behind the two tubes. Record the time t (in seconds) taken for the mixture in the first tube to become as colourless as the tube of C.

(iii) The experiment be repeated four times, using $5cm^3$ of A each time but varying the concentration of B by diluting it with deionised or distilled water as indicated in the table below. In each case find $\log_{10}t$, $-\log_{10}t$, and $\log_{10}V$ where V is the volume of B measured out.

Experiment No	Volume of A	Volume of B	Volume of H_2O	$\log_{10}V$	Time	$\log_{10}t$	$-\log_{10}t$
1.	$5cm^3$	$25cm^3$	$0cm^3$				
2.	5	20	5				
3.	5	15	10				
4.	5	10	15				
5.	5	5	20				

(b) (i) Calculate the percentage of oxalic acid consumed by the permanganate in the fifth experiment.

(ii) Plot a graph with $-\log_{10}t$ on the vertical axis and $\log_{10}V$ on the horixontal axis, and draw the best straight line through your points.

(iii) Calculate the gradient of your straight line, and correct your answer to the first place of decimals.

(iv) Write the rate law equation based on the balanced equation for the reaction.

(v) Using the gradient obtained in (iii) and considering the relative concentrations of the reactants, deduce from the equation obtained in (iv) the rate law that is valid for the reaction conditions of this experiment.

log 1/t = -logt; if log y = a log x, then $y = x^a$.

1. You are provided with following aqueous solutions:

Solution A Phenol

Solution B A Mixture of potassium bromide and potassium bromate

Solution C Sulphuric acid

Methyl red indicator.

You are required to find the value of the activation energy E of the reaction between aqueous bromate and bromide ions:

$$BrO_3^- + 5Br^- + 6H^+ \longrightarrow 3H_2O + 3Br_2$$

No previous experience in determining activation energies is required; full details of the method and calculations are given below.

PROCEDURE

(1) Fill one burette with the phenol solution A (CARE) and another with the bromide-bromate solution B.

Transfer into the FIRST boiling tube:

10.0 cm^3 of solution A

10.0 cm^3 of solution B

About 10 drops of methyl red indicator.

Transfer into the SECOND boiling tube:

5.0cm^3 of solution C (using a pipette).

Place both boiling tubes into a large glass beaker of water which is maintained between 49°C and 51° by careful warming. Suitably clamp the first boiling tube, containing A and B, and place a thermometer in this solution. When the temperature of this solution remains constant to within + 1°C within the range 49-51°C pour the entire 5.0cm^3 of the second boiling tube containing C into the clamped boiling tube and swirl gently. This clamped tube should remain in the water-bath throughout the experiment. Record the time, to the nearest second, from the moment of mixing to that of complete disapprance of the red colour; a white back-round may be helpful, Record also the temperature, to the nearest degree, of the contents of the clamped tube at the end of the experiment.

(2) Repeat this experiment at 45°C, 40°C, 35°C, 30°C

Record your results in the table below.

Experiment	Temperature (c)	Temperature (K) t	Time (Seconds) t	log 10^t	$\frac{1}{T}$
1					
2					
3					
4					
5					

In this experiment the actual values of the temperatures ($50^{\circ}C$ ... $30^{\circ}C$) was not critical. It is necessary to maintain steady temperatures, within the stated limits, near the temperatures. Thus, for example, the following temperatures would be satisfactory:

$49\ ^{\circ}C$, $44^{\circ}C$, $41^{\circ}C$, $35^{\circ}C$, $29^{\circ}C$

(3) Plot a graph of $\log 10^{t}$ (vertical axis) against $1/T$ (horizontal axis) and calculate the value of the activation energy E, assuming that the slope of the line is equal to $E/_{1}\ 2.3P_{1}$ The value of the ideal gas constant R may be taken as 8.3 J K^{-1} and thus

$E = 2.3\ R$ slope.

CALCULATION: .....

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(In the above experiment the formation for bromine is relatively slow. The reaction of bromine with phenol, however, is relatively very fast, and only when all the phenol has reacted will liberated bromine bleach the methyl red indicator).

APPENDIX C

EXPERMENTS CONTAINED IN THE EXPERIMENTAL UNIT QUALITATIVE ANALYSIS.

Qualitative Inorganic Analysis.

1. Introduction on anion analysis
   Co_3^{2-} HCO_3^- S^{2-} SO_3^{2-}
   demonstration and analysis of simple sults.
2. Anion analysis continued.
   Cl^- Br^- I^- SO_4^{2-} NO_3^-
3. Practice of the detection of anions.
4. Practice of the detection of anions
5. Introduction to cation analysis. Separation into groups Group I separation.
6. Demonstration and practice of separation of Group II cations
7. Demonstration and practice of separation of group III cations.
8. Demonstration and practice of separation of group IV cations.
9. Demonstration and practice of separation of Group V cations.
10. Demonstration and practice of separation of group VI cations

Qualitative organic analysis.

1. Detection of elements

   Halogens

   Nitrogen

   Sulphur

   Tast for saturated and unsaturated organic compounds.

2. Detection of functional groups

   Alcohol phenols aldehydes ketones.

3. Detection of functional groups

   Esters

   Carboxylic acid

   amino compounds

4. Detection of functional groups

   amines

   amides

   Nitro group.

5. Functional group analysis

   Glucose aretone acetamise

6. Practice on functional group detection

7. Practice on functional group detection

APPENDIX D

LIST OF EXPERIMENTS IN THE EXPERIMENTAL UNIT - PREPARATION OF COMPOUNDS

1. Inorganic preparation
   (a) Copper II amonium sulphate hexahydrate
   (b) Tetramine Copper II sulphate monohydrate.
2 Organic preparations
   (a) acetanilide
   (b) Benzanilide