EFFECTS OF INQUIRY AND LABORATORY METHODS OF TEACHING ON THE ACADEMIC PERFORMANCE OFSECONDARY SCHOOL CHEMISTRY STUDENTS IN ANAMBRA STATE, NIGERIA

BY

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B.Sc. (Chemistry Ed.) UNN

M.ED/EDUC/34479/12-13

AUGUST, 2017

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER'S DEGREE IN CURRICULUM AND INSTRUCTION

DEPARTMENT OF EDUCATIONAL FOUNDATION AND CURRICULUM, FACULTY OF EDUCATION

AHMADU BELLO UNIVERSITY,

ZARIA

AUGUST, 2017

DECLARATION

I hereby declare that the work in this dissertation entitled "Effects of Inquiry and Laboratory Methods of Teaching on the Academic Performance of Chemistry Students in Senior Secondary Schools in Anambra State, Nigeria" has been carried out by me in the Department of Educational Foundations and Curriculum. No part of this dissertation was previously presented for another degree or diploma in this or any other institution.

Joan Ifeanyichukwu	_____	_____
M.ED/EDUC/34479/12-13	Signature	Date

CERTIFICATION

This dissertation titled "Effects of Inquiry and Laboratory Methods of Teaching on the Academic Performance of Chemistry Students in Senior Secondary Schools in Anambra State, Nigeria" by Ifeanyichukwu Joan meets the regulation governing the award of Master's Degree in Education (Curriculum and Instructions) and is hereby approved for its contributions to knowledge and literary presentation.

Dr. A. Guga Chairman, Supervisory Committee	_____ Signature	_____ Date
Dr. A.F. Mohammed Member, Supervisory Committee	_____ Signature	_____ Date
Prof. B.A. Maina Head of Department	_____ Signature	_____ Date
Prof. K. Bala Dean, School of Post Graduate Studies	_____ Signature	_____ Date

DEDICATION

To the glory of God, this research work is dedicated to my loving mother Mrs. Juliana Nwawelu. My mother has not only been my source of logistical support, she has also taught me skills that have made me a better researcher. I learnt from my mum to work hard, to stand up for myself, the art of working around obstacles and the importance of just getting it done. Therefore it only seems right that I dedicate this dissertation to her.

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ABSTRACT

This study investigated the effects of inquiry and laboratory methods of teaching on the academic performance of chemistry students in senior secondary schools in Anambra state, Nigeria. The objective of the study was to determine and compare the academic performance of students taught using inquiry and laboratory methods of teaching as compared to conventional method. Four research questions and four hypotheses guided this study. Three schools were randomly selected with two as experimental groups and one control group. One hundred and fifteen (115) SSII students made up of three intact classes from co-educational schools in two educational zones of Anambra state. A quasi experimental pretest-posttest research design was used for the study. The two experimental groups were taught some chemistry topics using inquiry and laboratory methods while the control group was taught the same chemistry topics using conventional method for nine weeks. Chemistry Achievement Test was used as instrument for data collection. The research questions were analyzed using the descriptive statistics of mean, standard deviation, standard errors while the research hypotheses were tested using inferential statistics that involved independent t-test and ANCOVA at a significant level of 0.05. The findings of the study showed that students taught using inquiry and laboratory methods performed significantly better than those taught using the conventional method. Based on the findings, it was recommended that chemistry teachers should be encouraged to use inquiry and laboratory methods in teaching chemistry. Either or both experimental methods can be used in teaching both male and female students as they enhance students' performance irrespective of gender of the students. Government should provide adequate infrastructural and instructional materials for the effective teaching of chemistry.

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OPERATIONAL DEFINITION OF TERMS

The following terms were defined as used in this study

Inquiry Method: This is the art of asking questions. The strategy enables the learner to combine the search for knowledge in a systematic and logical fashion.

Laboratory Method: This refers to teaching method in whichthe teacher encourages students to derive various scientific laws and principles on their own by getting personally involved in the experiment work.

Conventional/Lecture Method: This refers to the classroom situation whereby the teacher as a subject matter expert presents topic content to the learners who in turn remain passive in the classroom without contributing in the process.

Teaching Method: The procedure a teacher follows in imparting meaningful knowledge to learners.

Academic Performance: This is the quantitative scores of students after they have been given a test of evaluation.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Education is the only wealth which cannot be robbed. It builds both internal and outer personality and character, strengthens people's mind and augments their pool of knowledge. The process of education aims at the all-round development of individuals, dispelling ignorance and enhancing the moral values in a society, thus working towards a collective well-being. Science education on the other hand helps students adjust to technological devices that affect their daily lives.

Science has been defined as the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence (British Science Council (BSC) 2009). Science can be said to be a human endeavour geared towards the development and comfort of the modern world. The foundation of this development is the primary and secondary school where the young scientists are groomed. Science in this way can be seen as the hub unto which development and progress of any nation depends. In general, science contributes towards improving the quality of life. It can therefore be asserted that science makes numerous contributions to healthy living. Therefore, it is important that effective ways are sought to provide for the effective teaching and learning of science in schools both for individual and national scientific development.

The knowledge that scientists have gathered about the world around us is organized under several subjects of which Chemistry is one. Chemistry is a branch of science that

systemizes the study of the composition of energy and transformation of matter. Chemistry as a branch of science is highly important in the modern society because of its requirement as a prerequisite to the study of many other science oriented courses. Furthermore, Chemistry is also one of the science major disciplines with well-developed technology that can be applied to exploit natural resources such as petroleum, natural gas etc. Chemistry plays a crucial role in industry in particular and national development in general. For example, the development of petrochemical, agriculture, medical, textile and many industries rely on and make use of the principles of Chemistry.

Some of the challenges faced in the society presently like global warming, terrorism, genetic modification, global market competition, energy and population crises, ethical issues among other critical issues require Chemistry knowledge, if they are to be dealt with rationally (Safeer and Keenan, 2005; UNESCO, 2010). Thus as modern economy is dependent on science and technology, a better understanding of Chemistry and better technical problem-solving skills will enable people to meet their challenges and demands of the work place. Furthermore, a modern knowledge-based economy will flourish only if it has a workforce with a high level of technical understanding and skills.It thus appears that for a nation to develop in science and technology, the teaching and learning of Chemistry need to be improved upon from what it is at present. It therefore becomes pertinent that achievement of students in Chemistry and in science generally should be of utmost consideration to any nation. However, the case is different in Nigeria because students' performances have not been encouraging. Majority of students consider the concepts involved in Chemistry as too abstract to understand and the content taught too difficult to learn. It is not a surprising thing that majority of Chemistry students in Nigerian

senior secondary schools have inadequate knowledge and understanding of Chemistry concepts and principles. Methodologies used in teaching Chemistry have been identified as one of the factors contributing to the poor performance of students in Chemistry among other factors. Thus, a teaching method that a teacher adopts may motivate students to learn or otherwise and therefore could make or mar students' achievement in Chemistry.

For the goal of education to be achieved, it is the responsibility of a subject teacher to help students attain maximum level in their learning tasks.Several competencies are expected of the teacher in order to achieve the desired goal especially in his/her area of specialization. Some of the competencies include ability to use appropriate instructional strategies in teaching, mastery of one's area of specialization, good leadership skills etc. In Nigeria, science teachers and in particular Chemistry teachers in secondary schools need to change their teaching methods to make them more effective and relevant to a much larger proportion of the students than in the past. This is because of rapid scientific and technological innovations over the past decades.

The relevance of Chemistry as a requirement for technological advancement of a nation cannot be underrated. The classification of any nation into developed, developing and underdeveloped could be measured accurately by the number of chemists, physics, engineers, pharmacists, doctors, agriculture and science educators the nation could produce. Available evidence from West African Examination Council (WAEC) indicates that students' performance in Chemistry, especially at the senior secondary school level worsen as years go by and many students seem to have negative attitude towards the subject (Betikin, 2002).There are various methods of teaching science. The modern science teaching methods should be organized to reflect the processes of science because to learn

science is to do science, and doing science by students entails more of providing opportunities for them to interact with the environment using the techniques and tools of science than memorizing scientific knowledge.

1.2 Statement of the Problem

This study intends to determine the effects oflaboratory and inquiry methods of teaching compared withthe lecture method on students' academic performance in Chemistry in secondary schools.Poor performance of students in Chemistry is increasing like in other science subjects. This has been attributed to many reasons and one of the outstanding ones is that poor method of teaching militates against its effective learning by the students. Chemistry as a subject aims at equipping learners with diverse skills, competencies and creativity needed to provide opportunities for wealth creation. These aims will remain a mirage if chemistry teachers do not incorporate the right methodologies needed for an engaged chemistry interactive classroom that will enhance performance of students in chemistry. Improvement on the method of teaching Chemistry was looked into in this study. The conventional instruction used all along had been found to be inadequate for effective teaching. This methoddoes not allow active students' participation in science lessons; rather, students memorize and regurgitate facts and concepts without the basic understanding of these concepts. Often too, students do not have the understanding of the scientific basis for the relevance of those concepts. According to Wolfe (2006), there are not enough instances when a teacher had tried to teach in an interesting way, say through activities and games.In view of the foregoing, it has become necessary to seek methodologies that will ensure and enhance better performance of students in chemistry.

1.3 Objectives of the Study

The study examined the effect of inquiry and laboratory methods on the performance of Chemistry students in senior secondary schools in Anambra State. Specifically, the objectives of the study were to:

1. Compare the performance of students taught with inquiry method and those taught with lecture method.
2. Compare the performance of students taught with laboratory method and those taught with lecture method.
3. Ascertain whether there is variation in the performance of students in experimental groups.
4. Compare the performance of students with respect to gender in the experimental groups.

1.4 Research Questions

The study answered the following questions:

1. Is there any difference between the performance of students taught Chemistry using inquiry method and those taught with lecture methods of teaching?
2. Is there any difference in the performance of students taught Chemistry using laboratory method and those taught with lecture methods of teaching?
3. Does the performance of students in the two experimental groups vary?
4. Is there any difference between the performance of male and female students in the experimental groups?

1.5 Research Hypotheses

The following hypotheses were tested at 0.05 level of significance in the course of the study:

Ho_1: There is no significant difference in the performance of students taught Chemistry using inquiry method and those taught with lecture methods of teaching.

Ho_2: There is no significant difference in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching.

Ho_3: There is no significant difference in the performance of students in the two experimental groups.

Ho_4: There is no significant difference between the performance of male and female students in the experimental groups?

1.6 Significance of the Study

Academic achievement of Nigerian students in school subjects including Chemistry at the secondary school levels has remained poor over the years.This could be as a result of poor mastery of the subject matter which occurs as a result of poor method of teaching. In the schools where active learning methods prevail, the students demonstrate significantly higher academic achievement to their counterparts. There is no doubt that the search for the effective teaching method in order to enhance academic performance of Chemistry students, improve competence in laboratory skills and activities is necessary. Inquiry and laboratory methods are quite effective in teaching of science and chemistry in particular. Consequently, the following benefits could be derived from the outcome of the study;

It is hoped that the study will encourage students to be actively involved in the construction of knowledge and to take charge of their own learning. Active participation of students

develops self confidence and positive attitude to science thereby enhancing performance. Therefore, the outcome of the study could enhance students' performance in Chemistry.

Chemistry teachers in secondary schools could also benefit from this study if they utilize the result from the study. This will guide them on how best to explore and sustain the interest of their students, thereby helping students conceptualize scientific concepts through activity oriented approach.

Curriculum developers like the Science Teachers Association (STAN), Nigerian Education Research and Development Council (NERDC) that determine what to include in the syllabus can recommend these methods of teaching and organize seminars for teachers in order that teachers can fully adopt the methods in order to promote the teaching and learning of Chemistry in schools. Also curriculum planners may not overload the curriculum content of chemistry at the secondary school level.

The nation at large could also benefit from the findings of this study as more capable manpower would be empowered through this holistic approach in teaching. This is because students will be able to apply theory in solving their everyday problem and also create job opportunities thereby creating wealth for the nation.

1.7 Basic Assumptions

The study made the following assumptions.

1. Teachers' involvement in seminars and conferences exposes them to the right usage of variety of teaching methods and materials that could promote more effective learning in Chemistry Education.
2. Curriculum of Chemistry at the secondary school level is overcrowded thus Chemistry teachers resort to faster way of finishing the curriculum content

3. Peer interaction encourages learning.
4. Students generally perceive science subjects as being difficult and Chemistry in particular but when they are made active participants in the class they tend to learn the subject better.

1.8 Scope of the Study

A study like this can cover the whole country but then due to limited time factor and financial constraint, the researcher made use of SS II Chemistry students in three secondary schools from two out of six different Educational Zones in Anambra State, Nigeria. The study was carried out with SSII students because they had studied Chemistry for one year and as such, they had the basic concept of Chemistry. The SSIII students were not part be of the study in view of the fact that they were preparing for an external examination (SSCE).

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

One of the principles of education in Nigeria is to equip every citizen with such knowledge, skills, attitudes and values that will enable him derive maximum benefits from his membership of society, have a fulfilling life and contribute towards the development and welfare of the community (FRN, 2004). Unfortunately, academic achievement of Nigerian students in school subjects including Chemistry at the secondary school level has remained poor over the years (Obika 2005).This could be as a result of poor mastery of the subject matter which occurs as a result of poor method of teaching. In order to remedy this ugly situation, the National Research Council (1996) emphasized an inquiry and laboratory based approach to science teaching in its National Science Education Standards.

According to Advanced Learner's Dictionary (2005), inquiry is the process of asking questions and studying in order to gather facts about something while laboratory experiment on the other hand is a test done in order to find or discover something. Therefore, inquiry and laboratory methods of teaching are methodologies that allow students to ask questions, find facts about questions raised and carry out tests in order to answer the questions, thereby finding solution to the problems. Nwosu and Okeke (1995) define inquiry method as a process through which learners are provided with opportunities to discover new truths, new rules and new methods of tackling a problem as well as new values for themselves.

In order to appreciate this research well the variables above (independent and dependent) are critically explained and the related experiences of the past writers on this topic

reviewed. The study reviewed some literature materials considered related to this study. This was done under the following subheadings: theoretical framework, methods of teaching Chemistry in secondary schools, evaluating Chemistry instruction, students' perception of Chemistry concepts, effects of inquiry method of teaching on the performance of students, effects of laboratory method on the performance of students, gender and academic achievement in science, and empirical studies.

2.2 Theoretical Framework

The theoretical framework of this study is linked to the learning theories of the following constructivists; Jean Piaget, Jerome Brunner, and John Dewey. Constructivists believe that all learners have the ability to construct knowledge in their own minds through a process of discovery and problem solving (Chowdlury, 2006). Constructivism views learning as a process in which the learning activity constructs or builds new ideas, concepts or experience. In other words, learning involves constructing one's own knowledge from one's own experiences. Constructivist learning therefore is a very personal endeavour, whereby internalized concepts, rules, and general principles may consequently be applied in a practical real- world context.

Piaget was the first psychologist to make a systematic study of cognitive development. His contributions include a theory of child cognitive development and detailed observational studies of cognition in children. According to Piaget, children are born with a very basic mental structure (genetically inherited) on which all subsequent learning and knowledge are based. He also theorized that children proceed through four distinct stages of cognitive development:

- The sensory motor stage (0-2yrs)

- The preoperational stage (2-7yrs)
- The concrete operational stage (7-11yrs)
- The formal operational stage (11 and above)

The education implications of this theory include:

1. Teacher should adjust the level of teaching to the operational level of children.
2. Careful observation of children is an effective guide to understanding their cognitive developmental level.
3. Instruction should be child-based rather than teacher-based

Educators assert that knowledge is enhanced when students are actively engaged n the learning process and when this is coupled with guidance from the instructor; students are able to gain a better understanding of science concepts (Correiro, Griffin and Hart 2008)

John Dewey believed that inquiry-based scientific approach could improve education. Dewey advocated that teachers should always let children use their natural activity and curiosity when learning about a new concept (Vandervoort, 1983; Dewey, 2008). Dewey also believed that the child should be given an opportunity where he/she can follow his/her interest. Teachers are advocated to create learning environment that motivates children. Teachers can bring the real life experience to the class which can provide a rich learning environment. Students also get more involved in higher order thinking when they see the teacher as a model (Wrenn, 2009).

Brunner's Theory of Instruction

Jerome Brunner argues that there can be a massive transfer of concepts, principles and strategies from one learning situation to another within the same discipline as well as between subjects. He was one of the founding fathers of constructivist theory. He argued

that intuitive and analytical thinking should both be encouraged and rewarded. Brunner believed the intuitive skills were under-emphasized and he reflected on the ability of experts in every field to make intuitive leaps. He investigated motivation for learning. He felt that ideally, interest in the subject matter is the best stimulus for learning. He did not believe in external competitive goals such as grades or class ranking. Brunner emphasized four characteristics of effective instructions and they include:

1. Personalized Instruction: instruction should relate to learners' predisposition and facilitate interest towards learning.
2. Content Structure: Content should be structured so it can be most easily grasped by the learner.
3. Sequencing: Sequencing is an important aspect for presentation of material.
4. Reinforcement: Rewards and punishment should be selected and placed appropriately.

Brunner is an advocate of discovery method of learning. Discovery involves all forms of obtaining knowledge for oneself by the use of one's mental ability. This approach is considered same as problem solving method and uses the discovery ability of students. Inquiry on the other hand emanated from discovery, it goes further than discovery in the sense that it involves finding some answers or reasons why a certain problem exists with a view to solving them. So to Brunner, important outcomes of learning include not just the concepts, categories and problem solving procedures invented previously by the culture, but also the ability to "invent" these things for oneself (McLeod 2012). Therefore this study will be anchored on the Brunner's theory of discovery learning because students will

be linking classroom teaching to real life situations using their natural ability instead of memorizing theories and principles.

Inquiry and laboratory methods are activity oriented methods of teaching that were examined in this study. They were used to describe teaching strategies that are driven by scientific inquiry and experimenting (Kahn & O'Rourke, 2005). The methods are deeply rooted in constructivist teaching practice which states that students are to be exposed to the real life problems and encouraged to construct, experiment and find solution on their own. They are student-centered rather than teacher-centered and offer students opportunities to be actively involved in experimenting, questioning and investigating.

These methods have been considered as being capable of promoting motivation among secondary school students since they create interest in the process of acquiring scientific knowledge and skills (Gibson and Chase, 2002). Supporting this, Sola and Ojo (2007) in their research findings state that inquiry and laboratory methods may be very effective in enhancing students' achievement and motivation to learn science as well as development of scientific process skills. High academic motivation has consistently been linked to increased level of students' academic achievement. Thus, the development of students' motivation in Nigerian secondary schools is a valuable objective for Chemistry teachers because of its inherent importance in enhancing students' performance in the subject.

2.3 Methods of Teaching Chemistry in Secondary Schools

The ultimate aims of education in every nation are to provide people with the knowledge of science needed for the fulfillment of the socio-economic and cultural needs of the society as well as ensure the means of physical survival. The Federal Government of Nigeria

seems to have realized these by stating in its National Policy on Education (2003) that one of the aims of education should be equipping students with worthwhile knowledge to live effectively in our modern age of science and technology. In view of these aims, the policy emphasized the need for effective teaching and learning of science in secondary and post secondary institutions.

Science and technology remains a priority aspect of the education policy but scientific literacy in Nigeria is still low in spite of the fact that science is being taught in schools. This could be as a result of the way science is being taught in the schools, which is done through mainly giving of laws, principles, theories and definitions which are unrelated to the experiences of students but only serves the requirements of Senior Secondary Certificate Examination (SSCE) (Aigboman 1985). This has caused some concerns to parents, government, educationalists and teachers. These concerns have helped to initiate some actions to improve on the present situation.

Activities by individuals and bodies like STAN, NERDC, etc., for the past two decades are aimed at stimulating interest in science at all levels of education. Aspects that have been looked into include; curriculum modification, innovation, teaching methods, teaching facilities, students' factors etc. Benson (1996) identified factors that contribute to high academic performance in examination. These include availability of qualified and experienced teachers, conducive and adequately equipped laboratories and textbooks. Other contributing factors include effective guidance and counseling services, good background in English language and Mathematics used in teaching the subject. James (1991) opined that teachers who provide good classroom conditions, good teacher/student relationship and apply suitable teaching methods may improve the academic performance

of students. Teaching methods were reviewed in this study to see the ones that are more effective in the teaching and learning of Chemistry.

Teaching methods can be seen as the totality of what a teacher does from the beginning to the end of a lesson. According to Dubey and Barth (1990), teaching methods refer to the general approaches of teachers as regards to the presentation of content. In most cases the teaching strategy of a teacher is determined by his philosophical conviction of the goal for teaching Chemistry and his own personal orientation. From the point of view of American Association for the Advancement of Science, AAAS, (1993), teaching methodology is a general term to cover everything a teacher does. In general teaching method refers to the systematic ways in which teachers approach their instructions (Fajola, 1996). Some of the teaching methods are reviewed below;

Expository/Lecture Method

Schön, (1983) defines the lecture method as a system by which a teacher impacts knowledge orally and ex-cathedral to his students who participate mainly by taking notes. Nwosu (1985) on the other hand, sees it as a teaching method where a teacher systematically unfolds a body of information or knowledge to his students who listen and takes down note. The lecture method has been most popular, most flexible, economical and time saving method used by most teachers. In fact, it is the conventional teaching method in most Nigerian schools even when it is considered as an old teaching method. In this approach, teachers present ideas and concepts, develop and evaluate them and summarize the main points at the end, while students listen and take down notes. In this method, students' questions are not normally encouraged and in cases where questions arise they are usually intended for clarification of facts and information and not for higher level

discussion. Lecture method is thus a teaching method in which knowledge and facts are presented, conveyed or transferred to the learners by the teacher who assumes the position of an "alpha and omega". He assumes a dominant and authoritarian position in the teaching-learning process.

In Nigeria, where educational system is very much examination oriented, teachers often consider lecture method as a choice and use the opportunity to try to cover as much of the syllabus as possible. Despite the advantage of covering much syllabus by the lecture method, it has the following disadvantages in teaching of chemistry: it makes learners passive than being active in the class, it kills the problem-solving attitude of learners as teacher dominates the entire teaching-process and also there is little or no interaction and cooperation between teachers and learners or among the learners. However, in spite of its outdated nature, and listed criticisms against its relevance in our modern day science teaching, critics of the method often find themselves lecturing.

Discussion Method

Literally speaking, when two or more people interact with each other verbally, they are said to be involved in a discussion. In the classroom, discussion of one type or another often takes place, sometimes deliberate, and at other times spontaneous. Unlike lecture method, discussion method is both teacher and student centred. It is based on the philosophy that knowledge arises within the person and from any external source (Kempa, 1990). Discussion simply means talking over subject from various points of view and the teacher's role is not to dispense or communicate knowledge but to act as a moderator.

Discussion is treated as an overall, step by step procedure of teaching a specific aspect of a subject in order to achieve definite instructional goals. It is therefore considered as a pre-

planned organized and unique method of teaching. Discussion implies that every student has background information that provides him with viewpoints. When a proper discussion takes place, students are free to share their views and they are motivated by the teacher's questions which makes them reason rather than recall. Also, the teacher does not indicate or influence the viewpoints of the students as he moderates the discussion.

Project Method

The project method can be defined as a unit of activity carried on by the learner in a natural and life-like manner and in a spirit of purpose to accomplish a definite, attractive and seemingly attainable goal. The project method is essentially a learning approach designed and conducted by students under the guidance of the teacher. The students, based on their background knowledge establish project goals, and they are encouraged by the teacher to work through study activities towards the attainments of those goals. Students working under the project method have more freedom and autonomy to decide on what they deem best. The students decide on what to work on, they also decide on how to collect their data and how to analyze the data collected. The teacher's main role is not to teach but to guide and advice, counsel and discuss with the students. The students produce a thesis, a model a written or oral report or some other piece of work.

Field Trip

Field trip is an organized visit to points of interest outside the classroom, such as factories, universities, project sites, museum etc. Iyewarun (1989) suggested that students' experience with their immediate environment constitutes one of their most valuable resources for learning. Effective and efficient teachers build or capitalize on such experience and use it for students' social and intellectual development as well as their

personal growth. Trips are often planned to places where the students will be able to see in practice or reality what they have studied in class. Concepts and generalizations, which were difficult to formulate, would become clearer once the students see working applications of those concepts. Field trips are organized to broaden students' general knowledge, but it should be quite clear that what they will learn from such trips will be educationally useful, and not just a waste of time and resources.

Henderson in Jekayinfa (2005) claimed that there are five stages in the effective handling of field trips and these are:

i. The need to obtain the factual background and technical skills required in understanding the specific purpose of the trip.
ii. Specific preparation and orientation prior to the trip. This includes a brief outline and purpose of the fieldwork to be given to the students by the teacher.
iii. The trip itself. Detailed planning is important and a recent visit by the teacher is essential.
iv. Follow up or post-field trip activities by the students to consolidate what they learnt in their previous visit.
v. Frequent references to the field work by the teacher to help the students assimilate what they observed.

Laboratory Method

This is basically a method that combines explanation, showing and doing for the benefit of the learners. In this method, the teacher leads students into carrying out experiments commonly referred to as practical. Farombi (1998) in Yara (2010) argued the saying that seeing is believing is the effect of using laboratories in teaching and learning science as

students tend to understand and recall what they see more than what they hear. Practical activities in teaching and learning of science have motivating effects on students. Therefore laboratory is very important and essential to the teaching of science and success of any science course is much dependent on the laboratory provision made for it.

Laboratory method is a problem solving method of teaching in which problems, scientific in nature or related to the real world, are carefully formulated and presented to the students. Ajewole (2000) in Bichi (2002) sees the development of science culture in the society as beginning in the classroom and the teacher being the key factor in its success. During practical session, the students interact with one another, with the scientific apparatuses and materials and ultimately construct knowledge and acquire science process. Laboratory method thus builds a bridge between science being taught in the classroom and its relevance to the real life. According to Hamidu, Ibrahim and Mohammed (2014), quality learning is achieved when science laboratory is made relevant in teaching and learning of science. Hence there is need for science practical sessions in teaching sciences in order to enhance creativity in the learner.

A working and vibrant school Chemistry laboratory should contain plenty of laboratory equipment. Osobonye (2002) in his research discovered that most secondary schools have Chemistry laboratory in their school while only 35% of them indicated they have enough equipment. According to Eule and Chukwu (2000) these material resources should be at the disposal of the teacher to use when the need arises. Researchers such as Onabanjo and Akinsola (2000); Oladare, Abiodun, andBajulaiye (2006); Akano and Akpolaere (2006), Adesoji (2006); Inyang (2006) and Ihuarulam (2008) stated that there are inadequate resources for teaching and learning of science subjects in public secondary schools in

Nigeria. They further stated that where there are little resources at all, they are not in good condition, while the few ones that are in good conditions are not enough to go round and also the few available material are dysfunctional. This is also noticed in other science subjects. Cirfat and Zumyil (2000) discovered that Biology laboratories in secondary schools are poorly equipped. Ajetumobi and Bashorun (2000) too reported the same lack of equipment for Agricultural sciences in secondary schools. Even in primary schools Uyoata (2006) reported that the science equipment is not adequate. In the laboratory a scientist requires basic tools. The Science Teachers Association of Nigeria has listed some of the most essential and frequently used tools (apparatus and chemicals) for teaching of 'O' level/senior Chemistry.

Where these materials are available the practical work should be effective if the teachers are serious. The availability of resources makes the work of a teacher to be easy; it makes the lessons to be concrete, simultaneous and helps to enhance the achievement of students in Chemistry. However, the studies of Onabanjo and Akinsola (2000) indicated that only blackboard and modern plane shapes, out of the whole resources were considered adequate in Oyo State secondary schools. Oladare, Abiodun, and Bajulaiye (2006) said that in Lagos State, schools had poor laboratory facilities as well as inadequate supply of chemical reagents.

Inquiry method

Inquiry is the art of asking questions. It involves careful observation and measurement, hypothesizing, interpreting and reflecting and recognizing the strengths and weaknesses of its own method (Huberman 2000). Inquiry method provides opportunities for students to work as scientists, investigating phenomena in a systematic way, and finding solutions to

scientific problems. Inquiry method promotes investigative thinking in the learner. Kazempour (2009) states that science teachers need to guide and facilitate learning and students need to take an active role in constructing their own learning experience. Also Kazempour (2009) states that there is need for teachers to receive professional development (PD) that brings about changes in their views about changes in their views about what enhances the students' learning experiences n the science classroom. Thoron and Myers (2011) agreed with Kazempour (2009) study by recommending that teachers receive PD in inquiry based instructions. Other methods designed to investigate the effectiveness of inquiry method of teaching include Haury (1993), as cited by Anderson (2002), which indicated that inquiry method increases conceptual understanding as well as improved attitude towards science (chemistry). Another study carried out was that of Tural, Akdenic and Alev (2010) who investigated the effects of using the 5E (Engage Explore Explain Elaborate and Evaluation) model of guided inquiry on student teachers' understanding of weightlessness and found that students improved and performed high. Inquiry method of teaching is found to be interesting and challenging therefore motivates students.

From the few teaching methods discussed above, it can be said that selection of the right methodology by the teacher will encourage high achievement by the students as no method is the best. Introducing different methodologies in the classroom can go a long way to help students have better understanding of the subject under study. Science teachers are encouraged to adopt the right teaching methods so as to help students have a deeper understanding and come to appreciate science subjects and Chemistry in particular. These and several other reasons have made science educators to advocate for instructional

procedures that stem from activity based instruction such as guided inquiry, problem solving, laboratory, field trip among others for effective teaching of science Okafor and Okeke (2006). Therefore chemistry as a science subject needs activity based methodologies such as inquiry and laboratory methods of teaching which are investigated in this study.

2.4 Evaluating Chemistry Instruction

Evaluation of classroom instruction helps to ascertain whether teaching-learning process is achieving what is meant to be achieved. A good number of authors and educational researchers have made visible efforts to provide a working definition of evaluation. Evaluation is perceived as a process for determining the achievement of goals, for collecting data concerning programme success (Megenity and Megenity, 1982) and as a judgment about people or event or extent of achieving designed outcome (Duke, 1987).

Evaluation is the life line to continual growth and accountability. It can be said to be a dimension of accountability, in that it is a process of institutional self-study to the institution and its members access the strengths and weaknesses of the institution or individual members and thereby improve their operations and programmes. She concluded that knowing whether a school is a good school, whether a teacher is a good teacher, whether students are learning what they should be learning and whether a programme of instruction is better than the replaced, are fundamental factors in evaluation. Hence, one can infer that evaluation like accountability is involved with the effectiveness and the worth of a programme, and a process of determining to what extent the educational objectives are actually being realized by the programme of curriculum and instruction. The concern of this definition was the role of evaluation in the whole educational set up. Earlier, Tuckman (1975) defined evaluation as a process wherein the parts, process or

outcome of a programme are examined to see whether they are satisfactory, particularly with reference to the stated objectives of the programme or the standards of excellence.

Stuffbeam and Webster (1980) perceived evaluation as a study designed and conducted to assist some audience to judge and improve the worth of educational objectives. Furthermore, Onwuka (1981) contended that the general concept of evaluation can be perceived as the frequent decision making which individuals, groups, institutions and governments pass on what affect their lives and those of others. In line with the above definitions, Akubue (2008) viewed evaluation as an appraisal of a fully developed programme in order to find out the effectiveness of the programme in terms of achieving the stipulated educational objectives and thereby arriving at decisions on how to improve the programme if found wanting. From the above definitions, evaluation could be said to be a process of finding out the decision to be made and determining to what extent the educational objectives are actually being achieved.

Evaluation serves a number of different purposes as it is related to the improvement of educational practices. Nothing contributes to success more than the knowledge of previous success. It is important to any individual learner or teacher to have information regarding how well his/her efforts are succeeding, and how he/she is being regarded and appraised by others. Evaluation thus serves as an essential diagnostic purpose. Through diagnosis, it is possible to identify strengths on which to build and weaknesses which need alleviating. Another purpose of evaluation is to maintain an awareness of the continuous relationship, which exists between educational objectives and educational achievement. Such awareness helps to ensure that teachers will view results of their teaching performance in terms of designated aims and within the total environmental situation.

Evaluation is very important in the classroom teaching as it is in all other fields of human endeavour. Whenever mention is made of evaluation, one of the things that comes to mind is, what is it that is being assessed? Teachers must endeavour to ask themselves questions such as "what did I teach today?" Every teacher should ask many of such questions every day, every month and every school year. He also asserted that teachers naturally want to see results, observe gains in behavior, note progress in acquisition of knowledge and bring about desirable changes and finally show evidence that these tasks are accomplished.

Evaluation specialists distinguish between formative and summative evaluation. According to Mkpa (1987), formative evaluation refers to gathering and using of information during an ongoing programme while summative evaluation is conducted to determine how worthwhile the final programme is. Summative evaluation leads one to three kinds of decisions at the completion of a programme: to continue it, to change it or to cancel it. Both formative and summative types of evaluation are necessary for the improvement of educational programmes. No one type of evaluation can be said to be sufficient considering the range of decisions taken in education.

For a learning outcome to be evaluated, it is necessary to bring in Taxonomy of Educational Objectives developed by Bloom over a period of years. According to the Taxonomy of Educational Objectives, abilities and learning were divided into three domains; the cognitive, the affective and the psychomotor. The cognitive domain includes the objectives which deal with the recall and the development of intellectual abilities. The affective domain includes the objectives that describe the changes in feeling, interest, attitudes, values and development appreciations. Psychomotor domain is concerned with the motor skills. Psychomotor skills are common to most subjects like writing, speaking,

and laboratory skills. When these three domains of education are met, educational objectives are achieved. Therefore, evaluation works side by side with objectives because it is through evaluation that one can determine whether the school or individual objectives have been achieved.

One of the primary purposes of evaluation is to provide a basis for curriculum revision and improvement. The purpose of evaluation is to provide and analyze data to produce a judgement concerning the merit worth, success and shortcoming of a proramme. One of the primary purpose of evaluation should be to improve teacher's effectiveness and not to weed out the unfit. Evaluation is a process which by implication is ongoing and not just to be used at the end of a unit work rather it is a process which is to be employed on a continuous basis. In Nigeria, the National Policy on Education (NPE 2003) makes the use of continuous assessment in both primary and post primary institutions and not just assessment at the end of the term work. Oral and other forms of evaluation should therefore be used at various times throughout the duration of teaching period.

Nworgu (2003:84-101) gave a more embracing definition of the term evaluation. According to him,

> *"The term evaluation is generally used in two senses. In the first sense, it is used to connote the process of making value judgments or taking decisions about events, objects or their character based on empirical data or information made available through measurement. Evaluation in this sense is purely qualitative and is preceded by measurement."*

Measurement makes available the pertinent information and evaluation judges the worth or value of that information. Evaluation therefore takes measurement a step further. It begins where measurement stops. Evaluation in the other sense of it continuing in Nworgu (2003)

> *"evaluation is also used in a broader and more encompassing sense as a process of seeking, obtaining and quantifying data with a view to making value judgement about objects, events or their characteristics."*

Conceptualized in this way, evaluation includes measurement and more; it is both quantitative and qualitative. Evaluation helps to improve the effectiveness of teaching and learning by aiding instructional supervision at the classroom level.

In the teaching-learning of Chemistry, evaluation plays an important role. It is through evaluation that the teacher learns to what extent the classroom instruction is achieving its objectives. Evaluation here can be formative or summative. Formative evaluation according to Ughammadu (1992) has relevance to continuous assessment which is currently practiced in Nigerian educational system. Therefore, through evaluation the strengths and weaknesses of Chemistry teachers can truly be ascertained in view of right methodology to be adopted in teaching Chemistry. The teacher teaching performance is rated based on how the teacher structures learning situations, the extent of student-teacher or teacher-student responses and the analysis of teacher behavior.

Trowbridge and Bybee (1996) identified six component of a model for standard science teaching in United States of America. These are:

i. teachers of science should plan inquiry-based programme for their students;

ii. teachers should interact with students to focus and support their inquires, recognize individual differences and provide opportunities for all pupils to learn;

iii. teachers should engage in ongoing assessment of their teaching and resulting students learning;

iv. conditions for learning should provide students with time, space, and resources needed for successful science learning;

v. teachers should foster habits of mind, attitudes, and values of science by being good role models for these attributes; and

vi. It is important for teachers to become active participants in on-going planning and development of the school science programme.

These bench-marks were derived from American Science Education Specifications; they are by no means limited to United States alone, they can also be recommended in Nigerian science classrooms. The realizations of these standards vary among nations because of variation in commitment to achieve and maintain set standards. Most poor nations lack resources to enforce standards in science teaching and learning. The practiced competencies of science teachers can be derived from what they actually do in schools and particularly in the science classrooms.

Although the National Policy on Education was launched in 1982 and by 1985 all states of the federation had joined in the implementation; it is regrettable to note that after this long, most research findings on the implementation of the policy indicate that most of the provisions in the policy are not adhered to. Ivowi (1997) noted that there is wide disparity in the concept of implementation amongst teachers, planners and administrators. The areas in science education practices which are not in conformity with the provisions in the

National Policy on Education range from methods of instruction to the exhibition of professional qualities in terms of activities and behaviour. Research results of Aminu (1980) have shown that science teachers continue to teach science using the lecture method despite the recommended inquiry/laboratory methods and the acceptance of these methods by teachers at organized training and orientation courses. The inability of science teachers to apply inquiry/laboratory approaches in their teaching is hinged on some teaching problems which include; lack of laboratories equipped with facilities in schools; large class sizes of science students with very few teachers and competency problems arising from the non training of science teachers.

Research evidences according to Ivowi (1997) now exist to suggest that students' misconception in Science and Mathematics may be due to poor teaching and that teachers do not seem to know the level of misconception in their students. Ajaja (1998) too f o u n d that chemistry students taught with inquiry/laboratory methods retained chemistry knowledge longer than those taught with lecture method. This tends to suggest that poor science learning by students could be traced to the teachers' fault-in the area of competences. This has led to a lack of proper exposure of science students to the processes of science, thereby leading to low performance among the science students.

2.5 Students' Perception of Chemistry Concept

Perception has been defined by Pomerantz (2003) as the process of attaining or understanding of the environment by organizing and interpreting sensory information. Perception involves the use of sensory organs to send information to the central nervous system and obtaining interpretation of same information from the central nervous system to the sensory organs. The Columbia Encyclopedia defines perception as the process of

mental organization and interpretation of sensory information. Perception is influenced by the way students view learning environment (stimuli) as presented by the teacher, this in turn determines their readiness to respond to the stimuli.

Concept of perception cannot be overemphasized in the study of Chemistry as students' achievement is to some extent being determined by their perception of the subject. Many students view and experience Chemistry as a difficult subject to understand because Chemistry has a lot of abstract contents with its technical terms which are very difficult for the students to relay with everyday life encounter. Also there is a lot of misconceptions of Chemistry among students. Agas (2003) pointed out that there are commonly observed perceptions among students particularly at secondary school level that Chemistry is not relevant to life. Chemistry causes social and environmental problems, Chemistry is difficult, Chemistry is about things rather than people and that chemists are generally odd people (Agas, 2003). How students perceive a subject is important, as perception affects achievement. Rivers (2001) in a study that investigated the effect of perception of Chemistry on the academic achievement in Chemistry found out that perception and beliefs about Chemistry have an influence on Chemistry achievement. A student with the most positive perception and beliefs about Chemistry will perform better in the subject and vice versa.

The teacher’s teaching style has some impact on students learning and the perceptions students develop about science learning. Teachers who are more inquiry and experimental oriented in their teaching will have students doing science similar to the way scientists actually conduct their affairs. (Finson, Thomas and Pederson, 2006). Conversely, teachers who are expositorier in their approach will have students engaged in learning that is less

like scientists actual work. Teachers that teach with inquiry and experimental methods of teaching tend to be those with positive attitude to science and science teaching and are effective teachers that have students who are successful in learning science (Rubeck and Enochs, 1991). The perception developed and held by the students taught with inquiry and experimental methods about science is more positive and therefore have greater achievement in science than students taught with conventional method of teaching.

2.6.1 Effects of Inquiry Method

Inquiry-based instruction is a student-centered and teacher guided instructional approach that engages students in investigating real world questions that they choose within a broad thematic frame work. Inquiry based instruction complements traditional instruction by providing a vehicle extending and applying the learning of students in a way that connects with their interests within a broad thematic frame work. Njoku (2004) stated that inquiry based learning is primarily a pedagogical method developed during the discovery learning movement of the 1960s a as response to traditional forms of instruction. Students use the inquiring process to develop ideas from their observations by integrating what they already know with what they have learned. They learn concepts in Chemistry skills and how to solve problems using practical approach. Inquiry based learning requires students to do more than just report on a topic. The students must go beyond the simple memorization of facts and regurgitation of information and into the realm of creating new and deeper understanding through identification and subsequent application of solutions to a specific topic.

The inquiry teaching method therefore is a teaching method that enables students to move step-by step from the identification of a problem defining the problem formulation

hypothesis, collection of data, verification of results, and generalization to the drawing of conclusion. Also Harbor-Peters (2000) pointed out that the inquiry teaching approach is techno-scientifically oriented. It places the learner's constructive mental ability first in all instructional processes. In other words it is learner centered.

Inquiry-based teaching method provides Chemistry educators with another teaching technique for developing life-long learners. They prove especially useful in delivering concepts that rely heavily on science. Teachers play a vital role in adapting the inquiry process to the knowledge and ability level of their students. When using inquiry-based lessons, according to Warner and Myers (2008) teachers are responsible for;

1. starting the inquiry process;
2. promoting student dialog;
3. transitioning between small groups and classroom discussions;
4. intervening to clear misconceptions or develop students' understanding of content material;
5. modeling scientific procedures and attitudes; and
6. utilizing student experiences to create new content knowledge.

Based on the objectives of the lesson and the abilities of the students, teachers must decide how much guidance they will provide. Nevertheless, regardless of the amount of assistance that teachers provide, the fundamental goal of inquiry is student engagement during the learning process. When incorporating inquiry-based methods into the classroom, teachers should ensure that each of the six stages of the inquiry cycle, as shown below, is complete. Six Stages of the Inquiry Cycle include;

1. Inquisition – stating a "what if" or "I wonder" question to be investigated

2. Acquisition – brainstorming possible procedures
3. Supposition – identifying an "I think" statement to test
4. Implementation – designing and carrying out a plan
5. Summation – collecting evidence and drawing conclusions
6. Exhibition – sharing and communicating results (Llewellyn, 2002, p. 13-14)

Inquiry-based learning approaches when correctly implemented can help develop higher-order, information literacy and critical thinking skills. They can also develop problem-solving abilities and develop skills for lifelong learning. This is illustrated in the quote below:

> *"Instead of thinking of a school as a place where 300 young people attend to be provided with an education, try thinking about a school as a research site, populated with 300 small sized researchers."*
>
> *"Rethinking the role of schools as producers of useful and valuable knowledge opens up many important questions. Equally, it positions schools as an important new resource for the community and provides students with valuable experience in serious knowledge work"*
>
> *Bigum (2003, p. 22-26)*

Through the process of inquiry, individuals construct much of their understanding of the natural and human-designed worlds. Some of the advantages of inquiry method of teaching include:

i. Instruction becomes students-centred. This is because students carry out investigation themselves.
ii. Students develop more interest in lessons because they are actively involved. Studies have shown that students become more enthusiastic when they carry out the learning activities themselves.
iii. Building in students self concept. That is, students are willing to take chances and explore, tolerate minor failures and are willing to learn more.

2.6.2 Effects of Laboratory Method

Laboratories are wonderful settings for teaching and learning science. They provide students with opportunities to think about, discuss, and solve real problems. Hamidu, Ibrahim and Mohammed (2014), opined that quality learning is achieved when science laboratory is made relevant in teaching and learning of science. Laboratory training is also frequently used to develop skills necessary for more advanced study or research.

Laboratory may be defined as a place equipped for experimental study, that is, the word laboratory in the minds of most people is synonymous with scientific investigation. A deeper understanding of the science and technology processes can be achieved through laboratory activities, which encourage active participation and serve to develop critical thinking. They provide concrete experiences to substantiate the theoretical aspect that has been taught. In adopting laboratory based methods, a teacher is expected to organize and structure instructional materials, select the experiments and subtly direct the activities so as

to stimulate the learners and contribute towards meaningful understanding of the subject being taught. These activities are not necessarily only class experiments and demonstrations, but they include those activities, which provide practice in designing experiments, operating and interpreting data, and thus lead to acquisition of suitable scientific skills and attitudes.

Since late in the 19th century, science educators have believed that the laboratory is an important means of instruction in science. Laboratory instruction was considered essential because it provided training in observation, supplied detailed information, and aroused pupils' interest. Science laboratory can be among the richest experiences students have at the university. It is one of the few opportunities students will have to practice science in a similar way that professionals do. In order for laboratories to be effective, students need to understand not only how to do the experiment, but why the experiment is worth doing, and what purpose it serves for improving students' understanding a concept, relationship, or process.

In Nigeria most modern science curricular emphasize students' involvement in science teaching through practical works in the laboratories. Examples of Nigerian science projects which place much emphasis on laboratory work are Nigerian Integrated Science Projects (NISP) developed by Science Teachers' Association of Nigeria (STAN) and the Nigerian Secondary School Science Project (NSSIP) developed by Comparative Education Study and Adaptation Centre (CESAC). Such emphasis is in keeping with the demand of science which requires certain skills to be developed in the students. Such derivable knowledge or skills include:-

a) The ability to plan an experiment and analyze the practical problem with its component parts.
b) The ability to perform experiment.
c) The ability to interpret the results of the experiment and draw conclusions.
d) Laboratory equipment are those items necessarily to be used in experimental work. (Ekwuozor, 1999).

Shulman and Tamir, in the Second Handbook of Research on Teaching (Travers, ed., 1973), listed five types of objectives that may be achieved through the use of the laboratory in science classes:

i. **Skills -** manipulative, inquiry, investigative, organizational, communicative
ii. **Concepts -** for example, hypothesis, theoretical model, taxonomic category
iii. **Cognitive abilities -** critical thinking, problem solving, application, analysis, synthesis
iv. **Understanding of the nature of science-** scientific enterprise, scientists and how they work, existence of a multiplicity of scientific methods, interrelationships between science and technology and among the various disciplines of science
v. **Attitudes -** for example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science.

2.7 Gender and Academic Achievement in Science

Academic achievement is affected by many factors such as motivation, student ability and the quality of education received among others. Educational achievement can be considered to mean the successful outcome of accomplished activities in educational

measurement in relation to accepted standards. Tests are conducted to know the rate of achievements of students in stated objectives. Sex difference in achievement and participation rates in science have been a subject of much research all over the world. Ditch and Scott, in Bichi (2002) stated that one controversy is that girls do not like practical work and as such cannot handle inquiry method. Also, according to Okiwo and Otubah (2007) gender has great influence on the students' achievement; boys perform better than girls in Physics. Due to constant debate gender academic differences poses in science achievement, some researchers have linked it to the way science is being taught in secondary schools. (Baker and Leary, 1995).

Study on trends in students' achievement in Integrated Science has shown that male students perform significantly better than their female counterparts. Greenfield (1996) in her study on science achievement it was discovered that males reported stereotype views of science than females. Also in a study by Oraifo (2005), pattern of performance among male and female students in science showed that there is a significant difference in the performance of male and female students in science in favour of males. Eriba and Sesugh (2006) too have reported that boys outperformed girls in science achievement. On the other hand, other researchers expressed different view point. Valanide (1996) did not find any significant difference on how males and females engage in reasoning process. In the likewise manner, the reports of David and Stanley (2002); Afuwape and Oludipe (2008), there is no longer significant difference in the cognitive, affective and psychomotor skill achievements of students in respect of gender. In the likewise manner, Ameh and Dantani (2012) too reported that the boys and girls are equally better in academic achievement when taught using inquiry and demonstration method.

Comparing the superiority of single gender group to the mixed gender, Woodward, Fergussan and Horwood (1999) indicated that students in single sex school performed better than students in mixed school. In supporting the above assertion, Njoku (2002) found that girls in single sex laboratory working group scored the highest mean in all the selected practical skills except in measurement skills. This means that girls in single sex group acquire more and better practical skills than their counterparts in mixed sex schools. Other researchers share different views. Inyang and Ekpenyong (2000) discovered mixed gender group achieved higher than each of the male and female groups. The higher mean difference recorded by the mixed gender group may be explained by the fact that high and low ability students obtain higher achievement scores after learning in mixed gender group. They maintained that as much as possible, mixed gender classes should be adopted in all science practical classes.

Lee and Burkam (1996) concluded that science laboratory experience and other hands-on-mind on learning, particularly in physical sciences could help to promote gender equity and science achievement in schools. Teachers are therefore encouraged to imbibe the culture of using inquiry and experimental methods of teaching while teaching science subjects. According to Levi (2000), the teacher plays a vital role in addressing the problem of gender equity in science education. To him there are two main roles a teacher must play;

- Ensure provision of equal opportunities and respects for differences in the classroom.
- Ensure that boys and girls have the same experience (treat boys and girls equally).

In this study, inquiry and experimental methods were used to ascertain the academic achievement of boys and girls in chemistry and also how the methods promote gender equity and science achievement in physical sciences and Chemistry in particular in secondary schools. The differences in the mean scores of gender academic achievement in Chemistry were investigated for the study.

2.8 The Empirical Studies

Academic performance refers to the quality of result produced by students as reflected in the quality of their examination scores. There have been various studies carried out to find out the factors that enhance the academic performance of students in science, Chemistry in particular. The study of Stephen (2008) showed that poor academic performance and unhealthy attitude towards science is as a result of ineffective teaching. The use of appropriate instructional methodologies, like laboratory, inquiry discovery and other activity based learning methods could enhance students' academic performance. Timothy (1991) studied the effectiveness of inquiry vs. lecture method of teaching Biology in secondary school. The result showed that inquiry method can enhance students' academic performance better than lecture method. Lagoke (1993) too studied the analogical linkage on socio cultural environment and biological concept attainment by secondary school students using a constructivist framework. The result showed that analogical linkage improves the performance of students in Biology. Furthermore, Ali (2013) examined the factors affecting students' academic performance in mathematical sciences. The result showed that applying inappropriate teaching method could lead to poor student academic performance

Lassi (1998) examined the use of laboratory teaching technique in facilitating effective communication link between the teacher and the learner in secondary school Chemistry. The study design was quasi experimental of pre-test, post-test and control group design. The sample of the study were drawn from the stratified sample, third year senior secondary school students that registered for SSCE, 1996 in Iwo Local Government, Osun State, Nigeria. In all, eighty students were involved in the study. Eighty students randomly classified into the experimental and the control groups were involved. Each group received ten sessions in five weeks. Pretest and posttest achievement tests were administered to the samples. The study revealed that the use of laboratory teaching technique is more effective in the teaching and learning of chemical concepts. The study is similar to the present study because it studied the effect of laboratory method of teaching on students' academic achievement and also used Chemistry as the subject under study but the present study is looking at two teaching methods, inquiry and laboratory methods.

Adesoji and Raimi (2004) studied the effects of enhanced laboratory instruction technique on senior secondary students' attitude towards chemistry in Oyo Township, Oyo state Nigeria. The aim of the study was to determine the effect of supplementing laboratory instruction with practical skill teaching on students' attitude towards chemistry. A total of 286 senior secondary class II students took part in the study Quasi experimental design of pre test post test was used. The results revealed that the use of enhanced laboratory instructional strategy significantly improved the attitudes of students towards chemistry. The study is similar to the present study because it studied the effect of laboratory method of teaching on students' academic achievement and also used Chemistry as the subject

under study but the present study is looking at two teaching methods, inquiry and laboratory methods.

Fruge (2007) examined the use of guided inquiry teaching method in local classrooms. He used survey as the design of the study and observed seven classrooms covering two Physics classrooms, one Mathematics class, one Biology class, one Chemistry class, one English class and one Psycholinguistics class. The Reformed Teaching Observation Protocol (RTOP) was used as an instrument for data collection. The RTOP data for each classroom were analyzed using Q-test. The results of the study revealed that the use of guided inquiry teaching method enhances effective teaching and learning. The similarity between that study and the present study is that the two encouraged inquiry based learning while they differ in the research design used by the researchers.

Okigbo and Osuafo (2008) also investigated the Effect of using Mathematics laboratory in teaching Mathematics on the achievement of Mathematics among junior secondary school students. The objective of the study was to determine the effect of laboratory teaching method in teaching and learning of Mathematics. A total of 100 JS 3 Mathematics students were involved in the study. The study was a quasi-experimental research. From the findings, it was observed that the use of Mathematics laboratory enhanced achievement in Mathematics. The results also showed that no significant difference exists in the achievement of male and female Mathematics students taught with mathematics laboratory. The study recommended that teachers should be encouraged to use Mathematics laboratory in teaching plane geometry and algebraic expression and Mathematics student teachers should be trained on its use in their methodology class. The study relates to the present in the sense that one of the methodologies under study, laboratory method, was studied in it

but they differ in the subject under review. Also, in the present study, the researcher studied two methods of teaching, inquiry and laboratory methods.

Similarly, Christy and Jonathan (2010) carried out a study on the impact of inquiry-based learning on the academic achievement of middle school students in Mathematics. The objective of the study was to determine the effectiveness of inquiry method of teaching in teaching of Mathematics. 36 science students were split into two groups of experimental and control groups. While the inquiry-based method was used in teaching the experimental group, the conventional method was used in teaching the control group. At the end, the whole students were given same test. The experimental group performed better than the control group. Result thus showed that students exposed to inquiry method pedagogy had a positive experience in the study of Mathematics. The study is similar to the present study in that both studies are about the effectiveness of inquiry method of teaching but they differ in the subject area; while the former was on Mathematics, the present study is in Chemistry.

Demircioğlu and Yadigaroğl (2011) studied the effect of laboratory method on high school students' understanding of the reaction rate in Anatolian High Schools in the city of Trabzo. The aim of this study was to investigate the effect of laboratory method on students' understanding of the subject of rate in chemical reactions. With this aim, a control group (12 boys, 5 girls) and an experimental group (10 boys, 9 girls) were randomly selected. Quasi-experimental design was used for the study. Two different instruments pre-test and post-test were used to collect data. The experimental group was taught with a teaching method based on laboratory while the control group was taught using the traditional approach. The collected data were analyzed by using the independent samples t test. The results showed that there is a significant achievement difference between the

experimental group that was taught with the laboratory teaching method and the control group that was taught with the traditional approach in favor of the experimental group. The study is similar to this study in that the two uphold laboratory method of teaching but differs in location of the study.

Khan and Hussain (2011) studied the effects of inquiry method on achievement of secondary school chemistry students. Objective of the study was to find out the relative effects of inquiry-based instruction on the academic achievement of secondary school chemistry students. The study was experimental in nature. Findings of the study showed that inquiry-based approach enhances students' academic achievement. The study relates to the present in the sense that one of the methodologies under study, inquiry method, was studied and also in the same subject but they differ in the number of teaching method under study, present study studied two methods of teaching, inquiry and laboratory methods.

Ameh and Dantani (2012) also investigated the effect of demonstration and lecture methods on the academic achievement of students in Chemistry in Nassarawa Local Government Area of Kano State. Fifty eight (58) Chemistry students (boys and girls) in Senior Secondary School One (SS1) from two randomly selected schools were involved in the study. Necessary data were collected and the validated reliable data were analyzed using t-test at a significant level of 0.05. Results obtained revealed that students perform better in Chemistry when taught using the demonstration method as compared to the lecture method. The boys and girls are better in academic achievement when taught using demonstration method than when lecture method was used. The demonstration method shows equality in the performance of boys and girls, hence the adoption of demonstration methods in the teaching and learning of Chemistry and science in general is hereby

recommended. The research is similar to the present research because the two encourage demonstration method which is similar to laboratory method in the present study. However, it differs from the present research because the present talks about inquiry and laboratory methods of teaching that could enhance students' achievement more effectively.

Likewise, Edinyan and Ubi (2012) studied the effectiveness of inquiry method of teaching social studies in junior secondary school. The objective of the study was to establish the fact that inquiry method of teaching helps students to learn social studies better. 300 students were used for the study and divided into two groups, experimental group and control group. Pre test was given to the two groups. The experimental group was taught by the researchers using inquiry method while the control was taught using expository method. After six weeks post test was given to the groups. It was observed that students taught with inquiry method outperformed those taught with expository method. Therefore the study showed that students achieve higher when inquiry method of teaching is used in teaching them. The study is similar to the present study in that both portray inquiry method of teaching over expository method. They differ also in the researchers' area of study; while the reviewed literature was on social studies, present study is on chemistry.

Aniodoh & Egbo (2013) investigated the effect of gender on students' achievement in chemistry using inquiry role instructional model. The study was to find the achievement levels of two groups of senior secondary schools students who were taught topics in chemistry using two different methods; the inquiry role instructional model and the expository teaching method. Senior Secondary II chemistry students were used for the study. Chemistry Achievement Test was used to collect for both pre test and post test. Findings show that students taught with inquiry role instructional model achieved higher

than those taught with expository method and that the female students performed better than their male counterparts taught with the inquiry role instructional model. The study is similar to the present study because it studied the effect of inquiry method of teaching on students' academic achievement and also used Chemistry as the subject under study but then the present study is looking at two teaching methods, inquiry and laboratory methods.

Bakke and Igharo (2013) too studied the effects of guided inquiry teaching method on students' achievement in logic. The study sought to find the achievement levels of two groups of senior secondary schools students who were taught a difficult concept in Further Mathematics using two different methods; the Guided Inquiry Teaching Method and the Conventional Teaching Method. 197 students were randomly drawn from senior secondary schools in Jalingo Education Zone of Taraba State, Nigeria. The study, which lasted for two months, generated data that was analyzed using mean, standard deviation and analysis of covariance (ANCOVA) with the pre-test scores as covariates at $(P \leq 0.05)$ probability level. The results showed that the students who were taught logic using the Guided Inquiry Teaching Method had better achievement scores than students who were taught using the Conventional Teaching Method. The study is similar to the present study because the two examined inquiry method of teaching but they differ in subject areas.

Namardha and Chamundeswari (2013) examined the effectiveness of constructivist-based teaching strategy on academic performance in Integrated Science by junior secondary school students in south-west, Nigeria. They used 120 JSS students as the sample size. The findings revealed that the constructivist instructed students had higher scores on the post test, compared to those exposed to lecture method of teaching. The authors concluded that if the Integrated Science teachers could incorporate constructivist-based teaching strategy

into their teaching methods, there could be an improvement in academic performance of JSS students in Integrated Science. The study of Namardha and Chamundeswari is similar to the present study because both of them emphasize hands-on activities for students so as to improve in their academic performance. They differ in that the former study was on junior secondary students and on Integrated Science; the present study is on senior secondary students and on Chemistry.

Ali, Bichi and Obeka (2014) studied the effects of inquiry teaching method on academic achievement and retention in chemistry among diploma students of Kano state Polytechnic. The study investigated the effects of inquiry method of teaching chemistry on students' academic achievement and retention among diploma II chemistry students. The study is a pre test post test posttest quasi experimental control design. A total seventy (70) students formed the sample of the study. The result of the study that students taught with inquiry teaching method outperformed their counterparts taught using lecture method and their level of retention of taught concepts was higher than those taught with lecture method. The study recommends among others that chemistry teacher should be encouraged to use inquiry method in teaching of chemistry. The study is similar to the present study because it studied the effect of inquiry method of teaching on students' academic achievement and also used Chemistry as the subject under study but the present study is looking at two teaching methods, inquiry and laboratory methods.

Njoroge, Changeiywo and Ndirangu (2014) carried out a research on the effects of inquiry-based teaching approach on secondary school students' achievement and motivation in Physics in Nyeri County, Kenya. Three hundred and seventy (370) students were used for the study and Solomon four non equivalent group as research design. Two experimental

and two control groups were set up and students drawn from four different schools were assigned to the groups. One group from experimental group and control group were pre tested after which the four groups were exposed to chosen topics in Physics but only experimental groups were taught using inquiry method of teaching. After four weeks a post test was given, the group taught with inquiry based method outperformed those taught with conventional method. . The findings of the study showed that Inquiry-Based Teaching (IBT) approach resulted into higher students' scores of achievement in Physics. The study recommends that teacher training institutions, Kenya Institute of Curriculum Development (KICD) and Physics teachers should enact IBT approach as the preferred Physics teaching approach in Kenyan secondary schools. The study is similar to the present because it studied the effect of Inquiry-Based Teaching on the higher students' achievement level in Physics which is one of physical science subject. However, it differs from the present study in that while the former was carried out in Physics, the present study is in Chemistry. Also, the country of the previous study was Kenya, the present study is in Nigeria.

Carrying out experiments in laboratory enhances cooperation amongst students. There is collaboration among them in order to carry out a specific task as students are mostly arranged in threes and fours during practical sessions. This is supported by the study on the effects of collaborating learning on Chemistry students' academic achievement in Balancing Chemical Equations in Secondary Schools in Katsina metropolis by Sabiru (2014). The study shows that students understand Chemistry concepts better when exposed to laboratory practical. The study sampled 80 SSII students, randomly selected from two senior secondary schools in Katsina metropolis. The two schools were randomly placed as experimental and control groups each with 40 students. A quasi-experimental pretest-

posttest research design was used for the study. The study subjects in the experimental group were taught using Collaborative Learning Concept of Balancing Chemical Equation, while the control group also was taught the same concept using traditional method for the period of six weeks. A Chemistry Achievement test was used as the instruments for data collection. Performance of the two groups were compared using post-test mean scores, and t-test unrelated sample, at a significant level (P) =0.05. The findings from the study show that those students taught using Collaborative Learning tend to achieve significantly higher and their anxiety was found to be low when compared with those taught using lecture method. Based on the findings, recommendations were made among which are: that Chemistry teachers should always use Collaborative Learning in teaching Chemistry concepts, as this method enhances students' achievement. The study is similar to the present study because it studied the effect of laboratory method of teaching on students' academic achievement and also used Chemistry as the subject under study but then the present study is looking at two teaching methods, inquiry and laboratory methods and also while the former study was carried out in the Northern part of the country, the present is carried out in the Southern part.

The study of Akani (2015) showed that the use of laboratory helps to develop scientific attitude in the students towards the learning of chemistry. The study was on the implication f laboratory teaching on students' achievement in chemistry in secondary schools in Ebonyi state Nigeria. It aimed at investigating the roles of laboratory in students' academic achievement in chemistry. A sample of 240 students was used for the study. Questionnaire was used for the collection of data. The study is similar to the present study because it studied the effect of laboratory method of teaching on students' academic achievement and

also used Chemistry as the subject under study while they differ in the research design used by the researchers.

Joseph (2015) carried out a research on the effects of laboratory and traditional teaching methods on students' academic performance in secondary school Chemistry in Kebbi State Nigeria. The study was carried out to determine the effectiveness of laboratory and traditional teaching strategies on students' academic performance in secondary school chemistry in Kebbi State. The Pre-test Post-test quasi experimental control design was used for the study. A population of 630 SS II students was used. Out of the population; two hundred and fifty two (252) senior secondary two students from three randomly selected schools were involved in the study. The students were assigned into two groups, experimental and control group. The experimental group was taught using Laboratory Method while the Control group was taught using the traditional teaching strategy. Pre and post tests were administered to both groups. Five hypotheses were tested. The data were analyzed using t- test at a significant level of 0.05 Results obtained revealed that students perform better in Chemistry when taught using the laboratory method as compared to traditional strategy. Boys and girls were better in academic achievement when taught using laboratory method. The laboratory method shows equality in the performance of boys and girls. A similarity between that study and the present study is that the two studied the effects of laboratory method of teaching on Chemistry students but they differ in their geographical region. That study was carried out in North West zone of Nigeria but the present study is in the South East zone.

Gambari, Obielodan and Kawu (2017) studied the effects of virtual laboratory on achievement levels and gender of secondary school chemistry students in individualized

and collaborative settings in Minna, Nigeria. The aim of the study was to investigate the effects of virtual laboratory on the achievement levels and gender of secondary school chemistry students in individualized and collaborative settings. 120 senior secondary II (SS II) chemistry students were randomly selected. The study employed quasi experimental design involving pre test post test design. The result showed that students exposed too chemistry using virtually laboratory package in collaborative learning setting outperformed their counterparts in individualized setting. Also there is no significant difference in the mean achievement scores of male and female students taught chemistry using virtual laboratory in collaborative setting but there is at significant difference in mean achievement scores of male and female students taught chemistry using virtual laboratory in individualized setting the study based on its findings recommended that the use of virtual laboratory instruction in collaborative setting should be encouraged in teaching chemistry at senior secondary schools in Nigeria. The study is similar to the present study because it studied the effect of laboratory method of teaching on students' academic achievement, used Chemistry as the subject under study and also studied the method with respect to gender but then the present study is looking at two teaching methods, inquiry and laboratory methods and also while the former study was carried out in the Northern part of the country, the present is carried out in the Southern part.

Considering gender achievement in Chemistry, many studies have been carried out to show whether there is gender difference in academic achievement in Chemistry. Akala (2010) conducted a research on gender differences in students' achievement in Chemistry in secondary schools of Kakamega District, Kenya. The study was a cross-sectional descriptive survey employing co relational methods to investigate gender differences in

Chemistry achievement levels of girls and boys. The study comprised twelve (12) stratified selected public secondary schools in Kakamega District. A total of 386 students responded to a five-item, Chemistry Achievement Test (CHAT) comprising descriptive, mathematical and spatial ability items. The students also responded to the Attitude Sale (AS), while their teachers filled the Chemistry Teachers' Questionnaire (CTQ) on the reasons for poor performance of students in Chemistry and their possible solutions. Quantitative data obtained from the CHAT were analyzed using Statistical Package for Social Sciences (SPSS). The study revealed the following findings; Gender was strongly associated with Chemistry achievement, as a result, boys' schools performed better than girls' schools. Boys had a stronger affinity and interest towards Chemistry. Teacher and school factors were of little effect on Chemistry achievement with respect to gender. The study is similar to the present study in that both studied gender achievement in Chemistry but differs in their research design. While Akala's study was a descriptive survey, the present study is a quasi experimental design using inquiry and laboratory teaching methods.

Udousoro (2011) also investigated the effect of gender and Mathematics ability on academic performance of students in Chemistry. The sample size comprised one hundred (100) SS 1 Chemistry students in two secondary schools in Uyo metropolis. The instruments used were the Chemistry Achievement Test (CAT) and the Mathematics Ability Test (MAT). Independent t-test statistic tool was used to analyze the data collected. The result of the test indicated that gender does not have any significant effect on the academic performance of students in Chemistry. It was also observed that students with high Mathematics ability performed significantly better than those with low Mathematics

ability in Chemistry. The study relates to the present study because both studied whether gender has influence on students' Chemistry performance but differ in that the former also looked into students' ability in Mathematics while the present study looks into effect of inquiry and experimental methods.

The available literature cited, indicate that selection of suitable teaching method will improve students' academic performance. The studies indicate that inquiry and experimental methods of teaching showed statistically significant results in areas dealing with scientific attitude, manipulation of apparatus and skills understanding over lecture method. Also studies have been reviewed on the effect of gender on academic achievement; most stated that there are significant differences in academic achievement and attitudes among the genders. However others differ in their opinion by stating that there is no significant difference with respect to gender in academic achievement of students.

2.9 Summary

From the literature reviewed, it can be said that lecture method is largely an inefficient method of motivating students to high academic performance in science. This is reflected in the poor performances of students at SSCE level and within the limit of available literature, it has been shown that inquiry and laboratory methods, if used effectively could go a long way to positively influence the understanding of science concepts.

Inquiry and laboratory methods make students very active and curious as the teacher withholds from them the concepts and principles they are to learn. The teacher's role is to guide and direct the students instead of dictating for them. The teacher does this by

introducing a lesson using appropriate teaching aid, gives students instances, examples and problems from which they deduce the concepts and principles. Through this method, students on their own carry out activities and experiments to find out solution to problems thereby discovering new truths, new rules and new methods.

Inquiry and laboratory teaching strategies engage the skills, interests and attitudes of the students in an interaction with the materials and the teacher. The methods allow the students to grow independently without restrictions to rigid procedures in procedures and syllabuses. Chemistry students' performance scores and analytical skills are either raised or greatly enhanced with the use of inquiry and laboratory methods of teaching. The researcher concluded that the hands-on-mind-on activities allow learners to construct context, and to develop positive attitudes towards learning.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This study aimed at finding the effects of inquiry and laboratory methods of teaching on the academic performance of Chemistry students in senior secondary schools in Anambra State. In this chapter, the methods and procedures employed in conducting the research were examined under the following subheadings: research design, population, sample and sampling procedure, instrumentation, validation, pilot Study, reliability of the instrument, procedure for data collection, and method of data analysis.

3.2 Research Design

The study adopted quasi experimental research design involving pre-test and post-test design. Secondary schools exist as intact groups, as such the school authorities do not normally allow the classes to be reconstituted for research purposes. The design allows the study of the participants in their natural setting. Using simple random sampling, schools were placed in three groups; experiment1 (E1), experiment2 (E2) and control (C) groups. The three groups were pretested to know their ability in Chemistry. The experiment group, E1 was then exposed to treatment (X1) which is teaching using inquiry method of teaching while E2 was exposed to (X2) laboratory method of teaching. The controlled group was taught with lecture method. At the completion of the period of teaching (nine weeks), the three groups were post tested to determine the effective of the treatments on the academic achievement of students in Chemistry. It is worthy to note that the same test given as a pre-test was also used as a post-test but the test items were reshuffled to minimize remembrance.

The design is represented as follows;

E_1 ⟶ $O_1\ X_1\ O_2$

E_2 ⟶ $O_1\ X_2\ O_2$

C ⟶ $O_1 - O_2$

Where

E_1 = Experiment group1

E_2= Experiment group2

C= Control group

O1= Pre-test

X_1= Treatment (inquiry method)

X_2 = Treatment (laboratory method)

O2= Post-test

3.3 Population

The population consisted of all 2015/2016 SSII chemistry students in Anambra State Senior Secondary Schools. There were six Educational Zones in Anambra State with 367 Senior Secondary Schools (Source: Anambra State Post Primary Service Commission, (ASPPSC) Awka). The schools were categorized into Boys', Girls' and Mixed schools. The population (of chemistry students) as at the time of conducting this research was sixteen thousand, five hundred and fifteen (16,515) (Source: ASPPSC Awka).

3.4 Sample and Sampling Procedure

From the six educational zones, two zones were randomly sampled. From the two zones, SSII Chemistry students from three mixed schools were sampled. This was to ensure that a

representative sample of the whole population with respect to gender was obtained. As such three mixed schools were used for data collection. SS II students were used because that is the class where Chemistry knowledge is consolidated in the students. Table 3.1 shows the sampled schools and number of students.

Table 3.1 Distribution of Sample Schools

SCHOOL	SCHOOL TYPE	NO OF STUDENTS	GROUP
Community Secondary School Ozubulu	Mixed	37	Experiment 1 Inquiry
Our Lady's Secondary School Nnobi	Mixed	38	Experiment 2 Laboratory
National Secondary school Nnewi	Mixed	40	Control Lecture

The total number of sample used is one hundred and fifteen (115). The sample size used was adequate following the recommendation by Gay, Mills&Airasian (2009) that a minimum of thirty students is satisfactory for an experimental study. The three sampled schools wereclassified as shown in Table 3.1. In all the schools, intact classes were used so as not to disrupt the organizational setting of the school.

3.5 Instrumentation

Two instruments were used for this study in order to generate relevant information. They are; Researcher's Instructional Package (RIP) and Chemistry Achievement Test (CAT). Researcher's Instructional Package which is a guided lesson plan using laboratory and inquiry methods of teaching, was developed and was given as treatment groups using the heuristics of solving Chemistry problems. This includes:

1. Definition of the problem
2. Selection of appropriate information
3. Combination of separate pieces of information
4. Evaluation.

Here two topics were used: identification of ions and chemical reactions. The choice of the topics in Chemistry was motivated by the following;

- Students encounter applications of the topics most often. Chemical reaction is applied in everyday life; the food people eat, burning of substances etc.
- Students are easily confused in the identification of different ions, thus need to concretize them.
- The topics are part of SS II Chemistry syllabus.

Chemistry Achievement Test (CAT) was used to assess students' achievement in learning the topics taught. For the purpose of standardization, the test items in CAT containing 30 multiple choice items were adopted from West African Examination Council past question papers. Furthermore, for the thirty (30) CAT questions, each correct answer has one mark, thus making a total of thirty marks. Items selected covered the topics taught.

3.5.1 Validation of the Instrument

The face and content validity of CAT was determined by the expert opinion of the following:

- Researcher's supervisors in Educational Foundations and Curriculum Department.
- Two secondary school Chemistry teachers with B.Sc (Ed) Chemistry and more than three years of teaching experience.

The instrument was revised based on corrections and recommendations made by the experts before its final production.

3.5.2 Pilot Study

A pilot study was conducbted in Community Secondary School Nnobi, Anambra State on thirty five (35) SS II Chemistry students comprising 19 females and16 males. The students were then taught Chemistry using Researcher's Instructional Package (RIP), that is, inquiry and laboratory methods developed by the researcher. The students were placed in groups to enable group activities. After six weeks, CAT was administered to the students to test their achievement level and re-administered again after two weeks to determine the reliability of the test.

Pilot study was conducted in order to

- Determine the reliability of the instrument.
- Identify problems or difficulties that respondents may encounter so as to minimize them.
- Asses the feasibility of the study.

3.5.3 Reliability of the Instrument

The reliability of the Chemistry Achievement Test (CAT) items was determined using the result of the pilot study. The mean and standard deviation of the test and re-test was used for the study. The results of the two tests were analyzed using Pearson Product Moment Correlation Coefficient (PPMCC) and it produced the reliability coefficient below.

Table 3.2 PPMCC Table

Test	Pearson Correlation Coefficient
1st Administration	0.95
2nd Administration	0.89

In PPMCC the strong positive association of variables has Pearson Correlation Coefficient of +1. From the table above, the correlation coefficient obtained from 1st and 2nd administrations of the instrument during the pilot study is 0.92. The reliability coefficient is adequate for the study because according to Olayiwola (2008), an instrument is considered reliable if it lies between 0.5 and 1 and that the closer the coefficient is to zero (0), the less reliable is the instrument but the closer the reliable is to one (1), the more reliable is the instrument. Therefore the coefficient is quite high and as such the instrument is consistent over time thus the CAT items were considered reliable for carrying out this study.

3.6 Procedure for Data Collection

A letter of introduction was obtained from the researcher's department to the relevant schools seeking their approval and permission to carry out the study. The treatment lasted for nine (9) weeks with three periods of forty minutes per week. The students in experimental groups were given pre-test and then taught the topics identification of ions and chemical reaction using inquiry and laboratory methods of teaching. These students were grouped into six groups for easy interactions among themselves and to carry out laboratory works more efficiently as they were exposed to inquiry and laboratory methods. One of the periods was set aside for class discussion while two periods were used for

brainstorming questions and practical. At the end of nine weeks CAT test (post-test) was administered to them. The control group was also given pre-test, after which they were taught using lecture method. The students in this group were taught the same topics as the experimental groups for a period of nine weeks. The researcher's lesson plan and note was used in teaching the control group. The researcher explained concepts and referred students to textbooks for further information. All groups (experimental and control) were taught by the researcher. This was to eliminate biasness should the researcher use research assistant. At the end of the nine weeks the students were post-tested with CAT test. The results from the pre-test and post-test were analyzed.

3.7 Treatment of the Experimental Groups

After administering pre-test to all the groups in the first week, treatment of the experimental groups began. The teaching of both experimental group 1 (inquiry method) and experimental group 2 (laboratory method) students lasted for a period of nine (9) weeks so as to effectively cover the sampled schools.

The first experimental group was exposed to inquiry method of teaching where students were challenged with series of questions that they brainstormed, such as;

- When is a reaction said to have taken place?
- Action of acid on CaCO3 is a vigorous reaction. Explain why a given reaction of acid and CaCO3 appears less vigorous.
- Determine the ions present in a given sample of salt and name the salt.

The second experimental group was exposed to laboratory method of teaching. Students in this group were presented with reagents like HCl, $CuSO_4$, NH_4OH etc. to carry out practical and to infer what happened when particular reagents are added together. The researcher

guided the students in both groups (through discussion) after their exposure to their respective treatments so as to achieve the researcher's specific objectives.

3.8 Method of Data Analysis

The result of students' performance in the Chemistry Achievement Test (CAT) was analyzed. The mean scores of pre test and post test of experimental and control groups were analyzed using inferential statistics involving t-test and ANCOVA. They were used so as to study the differences in the scores of control and experimental group and also to establish the level of significance at which the null hypothesis will be retained or rejected. Probability level of $P \leq 0.05$ was used in retaining or rejecting the stated null hypotheses.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the data analysis including the discussion of results. The data collected involved a total of 115 Chemistry students grouped into three. Their performance in Chemistry formed the data of this study. The first section presents the analysis of bio data variables and sex of the students. The second section contains answers to the four research questions using descriptive statistics of mean, standard deviation and standard errors. The third section presents results of the four null hypotheses tested at 0.05 level of significance.Hypotheses one, two and three were tested using independent t-test statistics while hypothesis four was tested with the Analysis of Covariance. The fourth section presents the summary and discussion of major findings.

4.2 Analysis of bio data variables

Table 4.2.1: Distributions of students by their treatment groups

Treatment Groups	**Frequency**	**Percentage (%)**
Inquiry teaching method	37	32.2
Laboratory teaching method	38	33.0
Conventional teaching method(control group)	40	34.8
Total	115	100.0

According to Table 4.2.1, the students were classified into three groups. The first 37 (experiment group I) representing 32.2% were exposed to inquiry method while the second group consisting of 38 (experiment group II)students or 33.0% of the students were

exposed to laboratory method. The remaining 40(control group) students representing 34.8% were taught with conventional (lecture) method of teaching.

Table 4.2.2: Distributions of Students by their Gender

Gender	Frequency	Percentage (%)
Male	65	56.5
Female	50	43.5
Total	115	100.0

On the students' gender status, a total of65 of them representing 56.5% were male Chemistry students while 50 representing 43.5% were female Chemistry students.

4.3 Research Questions

Research question One: Is there any difference between the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching?

Table 4.3.1: Descriptive statistics on difference in the performance of students taught Chemistry using inquiry method and those taught with lecture methods of teaching.

Variable	Groups	N	Mean	Std.dev	Std.Error	Mean differences	Remarks
Academic Performance	Inquiry	37	24.5676	4.0929	.6728	5.7675	Inquiry is higher than lecture method
	Control	40	18.8000	4.6143	.7295		

Table 4.3.1 revealed that there was differencein the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching. Their computed performance mean scores were 24.5676 and 18.8000 by students exposed

toInquiry method of teaching and those taught using lecture method, respectively with a mean difference of 5.7675 in favour of those exposed to Inquiry method of teaching.

Research Question Two: Is there any difference in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching??

Table 4.3.2: Descriptive statistics on difference in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching.

Variable	**Groups**	**N**	**Mean**	**Std.dev**	**Std. Err**	**Mean difference**	**Remarks**
Academic Performance	laboratory	38	23.7105	4.2421	.6882	4.9105	Laboratory method has higher performance than lecture method
	Control	40	18.8000	4.6144	.7296		

Table 4.3.2 revealed that differences existed in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching. . Their computed performance mean scores were 23.7105 and 18.8000 by students exposed to laboratory method of teaching and those taught using lecture method, respectively with a mean difference of 4.9105 in favour of those exposed to laboratory method of teaching.

Research Question Three: Does the performance of students in experimental group (Inquiry and Laboratory groups) vary?

Table 4.3.3: Descriptive statistics on the performance of students in experimental groups.

Variable	Groups	N	Mean	Std.dev	Std.Err	Mean differences
Academic Performance	Inquiry method	37	24.5676	4.0930	.6729	0.8570
	Laboratory method	38	23.7105	4.2421	.6882	

Table 4.3.3 showed thatacademicperformance of students in experimental groups slightly varied. Their computed performance mean scores were 24.5676 and 23.7105 by chemistry students exposed to inquiry method of teaching and those exposed to laboratory method of teaching respectively with a marginal mean difference of 0.8570 in favour of those exposed to Inquiry method of teaching. This implies that both experimental methods (inquiry and laboratory) had close positive effect on students' academic performance in chemistry.

Research Question Four: Is there any difference between the performance of male and female students in experimental groups?

Table 4.3.4: Descriptive statistics on the mean academic performance of male and female students in experimental groups?

Groups	Sex	Mean	Std. Deviation	N	Total Mean
Inquiry method	Male	24.7083	4.09113	24	
	Female	24.3077	4.25019	13	24.5676
Laboratory method	Male	24.6000	4.45327	20	
	Female	22.7222	3.87762	18	23.7105

In table 4.3.4, the mean and standard deviations show that there is slight difference between the performance of male and female students in experimental groups. The descriptive statistics showed that in Inquiry method the mean academic performances for male and female students were 24.7083 and 24.3077 respectively, clearly showing that there is difference of 0.4006.In the laboratory method, the mean academic performances for male and female students were 24.6000 and 22.7222 respectively, showing adifference of 1.8778 between them. This implies that in both inquiry and laboratory teaching method, the males performed slightly better than females with the difference being higher in the laboratory method.

4.4 Hypotheses Testing

Hypothesis One: There is no significant difference in the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching.

Table 4.4.1: Independent t test statistics on the difference in the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching.

Variable	Groups	N	Mean	Std.dev	Std.Err	Df	t calculated	t critical	P
Academic Performance	Inquiry method	37	24.568	4.093	.673	75	5.784	1.96	0.000
	Control	40	18.800	4.614	.730				

Calculated p < 0.05, calculated, t calculated > 1.96 at df 75.

Results of the independent t test statistics above showed that significant difference existed in the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching. This is because the p value of 0.000 is lower than the 0.05 alpha level of significance and the calculated t value of 5.784 is higher than the 1.96 t critical value at df 75. Their computed performance mean scores were 24.5676 and 18.8000 by students exposed to Inquiry method of teaching and those taught using lecture method, respectively. This implies that significant positive effect existed as a result of teaching chemistry with Inquiry method. Therefore the null hypothesis which states that there is no significant difference in the academic performance of chemistry students exposed to Inquiry method of teaching and those exposed to lecture method, is hereby rejected.

Hypothesis Two: There is no significant difference in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching.

Table 4.4.2: Independent t test statistics on the difference in the performance of

Variable	Groups	N	Mean	Std.dev	Std. error	Df	t cal	t crit	P
Academic Performance	laboratory method	38	23.711	4.242	.688	76	4.886	1.96	0.000
	Control	40	18.800	4.614	.730				

studentstaught Chemistry using laboratory method and those taught with lecture method of teaching.

Calculated p < 0.05, calculated, t calculated > 1.96 at df 76.

Results of the independent t test statistics above showed that significant difference existed in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching This is because the p value of 0.000 is lower than the 0.05 alpha level of significance and the calculated t value of 4.886 is higher than the 1.96 t critical value at df 76. Their computed performance mean scores were23.7105 and 18.8000 by students exposed to laboratory method of teaching and those taught using lecture method, respectively. This implies that significant positive effect existed as a result of teaching chemistry with laboratory method. Therefore the null hypothesis which states that there is no significant difference in the academic performance of chemistry students exposed to laboratory method of teaching and those exposed to lecture method, is hereby rejected.

Hypothesis Three: There is no significant difference in the performance of students in treatment groups.

Table 4.4.3: Independent t test statistics on the difference in the performance of students in treatment groups

Variable	Experimental groups	N	Mean	Std. deviation	Std. error	df	t calculated	t critical	P
Mean scores	Inquiry method	37	24.56	4.0929	.672	73	0. 890	1.96	0.376
	Laboratory method	38	23.71	4.242	.688				

Calculated p > 0.05, t calculated < 1.96 at df 73

Details of the independent t-sample statistics revealed that thereis no significant difference between the effect of inquiry and laboratory methods of teaching on students' performance. This is because the p value of 0.376 is greater than the 0.05 alpha level of significance, while the calculated t value of 0.890 was found to be lower than the t critical value of 1.96 at df 73.

Consequently, the null hypothesis which states that there is no significant difference between the effect of inquiry and laboratory method of teaching in influencing students' performance, is hereby accepted and retained.

Hypothesis Four: There is no significant difference between the performance of male and female students in experimental groups

Table 4.4.4: ANCOVA (Analysis of Covariance statistics) between the performance of male and female students in the two experimental groups

Tests of Between-Subjects Effects

Dependent Variable: scores

Source	Type III Sum of Squares	Df	Mean Square	F	.Sig.
Corrected Model	48.528[a]	3	16.176	.931	.431
Intercept	41406.436	1	41406.436	2382.112	.000
Sex	23.160	1	23.160	1.332	.252
Groups	12.800	1	12.800	.736	.394
sex * groups	9.734	1	9.734	.560	.457
Error	1234.139	71	17.382		
Total	44964.000	75			
Corrected Total	1282.667	74			

a. R Squared = .038 (Adjusted R Squared = -.003)

Estimated Marginal Means

Grand Mean

Dependent Variable: scores

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
24.085	.493	23.101	25.069

Outcome of the ANCOVA (Analysis of Covariance) statistics revealed that gender has no significant effect on the performance of students in experimental groups. Reasons being that the calculated p value of the gender versus experimental groups of 0.457 was found to

be higher than the 0.05 alpha level of significance. On individual factors analysis, it was found that the p value of gender was 0.252 and that of group analysis was 0.394 showing each to be higher than the 0.05 alpha level.Therefore, the null hypothesis which states that gender has no significant effect on the performance of students in experimental groups, is hereby accepted and retained.

4.5 Summary of Major Findings

The following are the summary of the major findings of the study;

1. Students taught with inquiry method performed significantly better than those taught with conventional (lecture) method. P = 0.000
2. Students taught with laboratory method performed significantly better than those taught with conventional (lecture) method. P = 0.000
3. Students taught with inquiry method performed significantly well, as those taught with laboratory method. P = 0.376
4. There was no significant difference in the performance of male and female students taught with inquiry or laboratory method. P = 0.457

4.6 Discussions of Major Findings

Result of research question one indicates thatthere was differencein the performance of students taught Chemistry using inquiry method and those taught with lecture method of teaching. Their computed performance mean scores were 24.5676 and 18.8000 by students exposed to Inquiry method of teaching and those taught using lecture method, respectively with a mean difference of 5.7675 in favor of those exposed to Inquiry method of teaching. The testing of hypothesis one through the independent t test statistics showed

that the difference in performance was signniificant. This is because the p value of 0.000 is lower than the 0.05 alpha level of significance and the calculated t value of 5.784 is higher than the 1.96 t critical value at df 75.The finding agrees with the findings of Christy and Jonathan (2010)that students exposed to inquiry method had a positive experience in the study of Mathematics;agrees with that of Khan and Hussain (2011) that inquiry method of teaching enhances learning. Again the study ofNjoroge, Changeiywo and Ndirangu (2014) also showed that Inquiry-Based Teaching (IBT) approach resulted in higher students' scores of achievement in Physics. Supporting the effectiveness of inquiry method, Ali, Bichi and Obeka (2014) who studied the effects of inquiry teaching method on academic achievement and retention in chemistry among diploma students of Kano state Polytechnic found that students taught with inquiry teaching method outperformed their counterparts taught using lecture method and their level of retention of taught concepts was higher than those taught with lecture method. These studies therefore show that performance of students is more enhanced if inquiry method of teaching is used in the teaching and learning of Chemistry.

Result of research question two showed thatdifferences existed in the performance of students taught Chemistry using laboratory method and those taught with lecture method of teaching. . Their computed performance mean scores were 23.7105 and 18.8000 by students exposed to laboratory method of teaching and those taught using lecture method, respectively with a mean difference of 4.9105 in favor of those exposed to laboratory method of teaching.Analysis of hypothesis two using independent t test showed thatdifference in performance was significant. This is because the p value of 0.000 is lower than the 0.05 alpha level of significance and the calculated t value of 4.886 is higher than

the 1.96 t critical value at df 76. Thus laboratory method enhances the performance of students exposed to it than those exposed to the lecture method. The findings of Demircioğlu and Yadigaroğl (2011)on the effect of laboratory method on high school students' understanding of the reaction rate in Anatolian High Schools in the city of Trabzo showed that there is a significant achievement difference between the experimental group that was taught with the laboratory teaching method and that of the control group that was taught with the traditional approach in favor of the experimental group supports this finding. The finding also agrees with that of Sabiru (2014) who found that conducting experiment in the laboratory enhances cooperation amongst students thus leading to better understanding of Chemistry.Also the study of Akani (2015) showed that the use of laboratory helps to develop scientific attitude in the students towards the learning of chemistry. Joseph (2015) investigated the effectiveness of laboratory and traditional teaching strategies on students' academic performance in secondary school chemistry in Kebbi State. The findings showed that boys and girls were better in academic achievement when taught using laboratory method. These therefore show that performance of students are enhanced if laboratory method of teaching is used in the teaching and learning of Chemistry.

Finding from third research question showed that thedifference between the effect of inquiry and laboratory methods of teaching onstudents' performance is negligible. Their calculated mean scores were 24.567 and 23.710 by students in the inquiry and laboratory groups respectively. Similarly, hypothesis analysis showed that calculated p value of 0.379 is greater than the 0.05 alpha level of significance and also the calculated t value of 0.890 is lesser than the critical t value of 1.96 at df 73. These imply that both teaching methods had

almost the same effect on students' performance. Both teaching methods are activity based methodologies; as such enhance students' active participation in the classroom which in turn leads to higher performance. This agrees withOkigbo and Osuafo (2008) in their study of effect of laboratory teaching method in teaching and learning of Mathematics;thefindings showed that the use of Mathematics laboratory enhanced achievement in Mathematics. On the other hand, the study of Aniodoh & Egbo (2013) investigated the effect of gender on students' achievement in chemistry using inquiry role instructional model and found that students taught with inquiry role instructional model achieved higher than those taught with expository method in support of present study. This finding also agrees with one of the basic assumptions of this study; that students generally perceive science subjects as being difficult and Chemistry in particular but when activity-based teaching methods like inquiry and laboratory methods are used in the classroom, they are made active participants in the class and as such tend to learn the subject better. Thus both inquiry and laboratory methods of teaching enhance chemistry performance.

Result of research question four indicated that gender has no effect on the performance of students in experimental groups. The descriptive statistics table of scores showed that among the experimental group I the scores for males and females were 24.7083 and 24.3077 respectively. On the other hand among the experimental group II the scores for males and females were 24.6000 and 22.7222 respectively. From the analysis of hypothesis four, the calculated p value of the gender versus experimental groups of 0.457 was found to be higher than the 0.05 alpha level of significance. On individual factors analysis, it was found that the p value of gender was 0.252 and that of group analysis was 0.394 showing each to be higher than the 0.05 alpha level. This therefore implies that gender had minimal

effect on the performance of the students exposed to both inquiry and laboratory methods. The finding agrees with the findings of David and Stanley (2002) who found that there is no significant difference in the cognitive, affective and psychomotor skill achievements of students in respect of gender. Also, Udousoro (2011) investigated the effect of gender and Mathematics ability on academic performance of students in Chemistry. The result of the test indicated that gender does not have any significant effect on the academic performance of students in Chemistry. Thus the study established that gender has no significant effect on the academic performance of students. Both genders therefore should be exposed to same classroom experience without discrimination. Joseph (2015) investigated the effectiveness of laboratory and traditional teaching strategies on students' academic performance in secondary school chemistry in Kebbi State. The findings showed that boys and girls were better in academic achievement when taught using laboratory method, and that laboratory method shows equality in the performance of boys and girls. But then the finding of Akala (2010) differs from the study. The research conducted on gender differences in students' achievement in Chemistry in secondary schools revealed the following; Gender was strongly associated with Chemistry achievement, as a result, boys' schools performed better than girls' schools. Boys had a stronger affinity and interest towards Chemistry and as such performed better than girls in Chemistry. However, Ekpeyong (2000) shared a different view and discovered that mixed gender group achieved higher than each of the male and female groups. From the above studies, the researchers all agreed that students exposed to classroom experience that involves critical thinking and solving problem through active involvement and sharing of ideas among themselves irrespective of gender performed better.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study investigated the effect of Inquiry and Laboratory methods of teaching on the academic performance of senior secondary school Chemistry students in Anambra State. During the course of this, four objectives were formulated which are: to compare the performance of students taught with inquiry method and those taught with lecture method; compare the performance of students taught with laboratory method and those taught with lecture method; ascertain whether there is variation in the performance of students in experimental groups; and compare the performance of students with respect to gender in the experimental groups.

Four research questions and four hypotheses were generated in line with the objectives. Quasi experimental pre-test post-test that involved two experimental groups and one control group was used for the study. The experimental groups were taught using inquiry and laboratory method of teaching while the control group was taught using conventional method of teaching. Population of the study comprised of all the SSII Chemistry students in Anambra State Senior Secondary Schools. Random sampling technique was used to select three co-educational schools from two educational zones out of six in the state. The total number of sample used was one hundred and fifteen (115). Two research instruments were used for the study; Researcher's Instructional Package (RIP) and Chemistry Achievement Test (CAT). RIP was developed by the researcher using inquiry and laboratory methods covering different topics in Chemistry and it was used in teaching experimental groups. CAT was used to collect data from the experimental groups and the

control groups. It comprised of thirty questions covering the topics students were taught. Pilot study of the CAT items was conducted using a school that was not part of the study and reliability coefficient of 0.92 was obtained. Analysis of the data collected was done using different procedures. The bio data variables were analyzed by means of frequency and percentages. Research questions were analyzed using descriptive statistics of mean, standard deviations and standard errors. Research hypotheses were tested using inferential statistics. Hypothesis one, two and three were analyzed using independent t-testwhile hypothesis four was analyzed using Analysis of Covariance (ANCOVA). Based on the analysis, it was established that inquiry and laboratory methods of teaching enhance learning of chemistry, there is minimal difference between students taught with inquiry method and those taught with laboratory method of teaching in favour of inquiry method of teaching and also male and female students performed better when taught with inquiry and laboratory methods of teaching though males performed slightly better.

5.2 Conclusions

On the basis of the findings of this study, it can be concluded that each of the three methods used resulted in some improvement in the performance of students in chemistry. However if chemistry is taught using either inquiry or laboratory methods, the performance of students will be much better. Thus while the use of conventional method should not be discarded, the more frequent use of inquiry and laboratory methods will immensely enhance performance in chemistry.

5.3 Recommendations

The following recommendations are put forward as a result of the outcome of this analysis

1. Teachers should intensify efforts in the use of inquiry and laboratory methods in teaching chemistry in Secondary schools.
2. Chemistry teachers should be sent on seminars and workshops where modern and effective teaching methods are discussed to enhance their teaching
3. Government should provide all the necessary facilities and materials needed for the full and effective implementation of these modern teaching methods such as the inquiry and laboratory teaching methods.
4. The use of laboratory and inquiry teaching methods should be employed in both male and female secondary schools, as these two methods are gender friendly.

5.4 Suggestions for further studies

The study is by no means exhaustive; the following are suggested for further studies.

1. Further studies can be carried out on the relationship between the effective use of inquiry and laboratory teaching method and teachers teaching requisite qualification and experience on students academic performance in Chemistry among senior secondary students in Anambra State.
2. A similar study could be conducted in the primary and junior secondary schools in Nigeria using Basic Science.
3. Other teaching methodologies in Chemistry could be studied to also see their effectiveness in teaching and learning of chemistry.

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APPENDIX I

INQUIRY METHOD LESSON PLAN 1

TIME: **80Minutes (double periods)**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Chemical Reaction**

INSTRUCTIONAL MATERIALS:

Reagents like HCl, CuSO4, NaCO3, NH4OH, stop watch, source of heat, test tubes beakers.

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, the students will be able to

1. Name the reactants and products of a given chemical reaction

2. Write a balanced equation of the reaction.

ENTRY BEHAVIOUR:

Students have learnt names of common reagents in the laboratory

INTRODUCTION:

Researcher introduces the lesson by explaining to students they like known scientists are going to make some findings and from their findings make innovations that can change the world. Researcher asks students the following questions in order to arouse their interest.

1. How many students have used non-rechargeable battery torch?
2. How bright is the flashlight when the battery has stayed for days?
3. What caused the change in the brightness of the torch?

CLASS PRESENTATION:

Step 1:

Researcher asks students more questions to arouse their inquiry ability:

1. Will torch give light without battery?
2. When the positive and negative ends of battery are misplaced in a torch, will the torch still give light?
3. What is the content of battery that makes it very important?

Step 2:

Researcher acting as a facilitator allows students to adequately respond to each of the questions above, and also discusses the different ideas together with students. She explains to the class that the content of the battery undergoes chemical change in order that torch can give light. This change is known as chemical reaction.

Step 3:

Researcher shows and names different reagents to students. She takes little quantity of HCl and NaCO3 and mix them together and writes the equation for the reaction on the board. She asks students to explain and discuss what they observed. Teacher explains to the students that the initial substances are the reactants while the new one formed is the product. She therefore asks students to;

- Mention the reactants and the product of the reaction.
- Explain what they understand by a chemical reaction.

Conclusion:

Teacher concludes the lesson by asking students to write down the reactants and products of some given reactions and write their balanced equations.

INQUI RYMETHOD LESSON PLAN 2

TIME: **80Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Chemical Reaction**

INSTRUCTIONAL MATERIALS:

Reagents like HCl, CaCO3, NH4OH, stop watch, source of heat, test tubes beakers.

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to explain

1. the reaction time

2. the rate of chemical reaction

ENTRY BEHAVIOUR:

Students have learnt about chemical reaction. They can identify the reactants and the products from a chemical equation.

INTRODUCTION:

Teacher introduces the lesson by asking provide answers to the following;

1. How long does it take a piece of iron to rust when exposed to air and moisture?
2. How long will it take this same piece of iron to burn when heated?
3. What effect has increase or decrease of heat has on boiling water?

CLASS PRESENTATION:

Step 1:

Together with the students teacher discusses various answer given by the students. She explains further that rusting and burning are two reactions a piece of iron undergoes; that while burning is fast, rusting is a slow reaction. Teacher explains that time taken for a reaction to take place is called rate of chemical reaction.

Step 2:

Teacher shows students a lump and powdered forms of CaCO3 and dil. HCl; she pours a little amount of dil. HCl in two test tubes and label them A and B. into test tubes A and B, add equal amount of lump and powdered forms of CaCO3 respectively. Teacher asks the following questions:

1. Explain what happened in each of the test tubes
2. Why is one more vigorous than the other?
3. Explain rate of chemical reaction using the two reactions.

Step 3:

Teacher guides students in deciding how to answer the questions by asking them to think critically in order to arrive at correct answers. She also answers students questions and explains facts for clarifications and better understanding.

Conclusion:

Teacher asks students to write down their answers. Closing their note books she asked students to explain rate of chemical reaction.

INQUIRYMETHOD LESSON PLAN 3

TIME: **80Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Factors Affecting Rate of Chemical Reaction**

INSTRUCTIONAL MATERIALS:

Reagents like HCl, CaCO3, CuSO4, stop watch, source of heat, test tubes beakers.

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to mention and explain the factors affecting rate of chemical reaction.

ENTRY BEHAVIOUR:

The students have known about the rate of chemical reaction

INTRODUCTION:

Teacher introduces the lesson by asking the following questions;

1. What are the findings of the last experiment?
2. What caused changes in the two test tubes in the last experiment.

Teacher examines the information students have provided and discusses the different ideas together with the students.

CLASS PRESENTATION:

Step 1:

Teacher poses these questions to stimulate the learners to continue their discovery process:

1. Is there any need of reaction rate in our everyday lives?
2. What are the things that makes a reaction to be fast or slow?
3. Why do you think we heat food or put in freezer for preservation?

Step 2:

Students are given time to think and respond to the questions. Should they fail in their response, guidance is given towards the right direction. This way factors that affect rate of chemical reaction are known.

Step 3:

Teacher asks students following questions to brainstorm:

- What is effective collision and collision theory?
- How do factors named above affect collision?
- What is the relationship between effective collision and rate of chemical reaction?

Teacher helps students in answering the above questions by encouraging student-student interactions without noise making and also use of their textbooks.

Conclusion:

Teacher asks students to write down their answers in their notes and bring it to next class for discussion.

INQUIRYMETHOD LESSON PLAN 4

TIME: **80Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Identification of Ions**

INSTRUCTIONAL MATERIALS:

NaOH, salts, beakers, NH4OH, test tubes

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to identify cations present in a given salt

ENTRY BEHAVIOUR:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

INTRODUCTION:

Teacher asks students to name different sense organs of the body and their functions. She opens ammonium hydroxide solution and asks students what they observed. She goes on to explain that scientists make use of five sense organs to observe their environment. She asks students again to observe their environment and report their findings.

CLASS PRESENTATION:

Step 1:

Displaying different unlabelled samples and some reagents, teacher explains that reagents when added to samples are used in determining ions present in a sample. Teacher divides

the class into six groups and asks each group to identify metallic ions (cations) present in sample given to them. She encourages students to consult different texts to guide them in determining tests for different cations.

Step 2:

Students are given ample time to come up with their observations. Teacher calls for class discussion as each group presents their observations. As a facilitator teacher acknowledges the right answers and supervise those that could not get the right answers so that right answers is got and explanations given to students.

Conclusion:

Teacher asks students to write down their conclusions.

INQUIRYMETHOD LESSON PLAN 5

TIME: **80Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Identification of Ions**

INSTRUCTIONAL MATERIALS:

HCl, salts, beakers, NH4OH, test tubes

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to identify anions present in a given salt

ENTRY BEHAVIOUR:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

INTRODUCTION:

Teacher asks students to name reagents needed to test for cations. She asks them if they have seen laboratory technicians carrying out such tests. Teacher explains that cations alone cannot determine a particular sample; test for anions (non-metallic ions) must be carried out too.

CLASS PRESENTATION:

Step 1:

Displaying different unlabelled samples and some reagents, teacher explains that reagents when added to samples are used in determining ions present in a sample. Teacher divides the class into six groups and asks each group to identify non-metallic ions (anions) present

in sample given to them. She encourages students to consult different texts to guide them in determining tests for different anions.

Step 2:

Students are given ample time to come up with their observations. Teacher calls for class discussion as each group presents their observations. As a facilitator teacher acknowledges the right answers and supervise those that could not get the right answers so that right answers is got and explanations given to students.

Conclusion:

Teacher asks students to write down their conclusions.

APPENDIX II

LABORATORY METHOD LESSON PLAN 1

TIME: **80Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Chemical Reaction**

INSTRUCTIONAL MATERIALS:

Reagents like HCl, CuSO4, NaCl, NH4OH, stop watch, source of heat, test tubes beakers.

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, the students will be able to

1. Name the reactants and products of a given chemical reaction

2. Write a balanced equation of the reaction.

ENTRY BEHAVIOUR:

Students have learnt names of common reagents in the laboratory

INTRODUCTION:

Teacher asks students to mention different reagents found in the laboratory. She displays different reagents in well labeled beakers. She carries out simple experiment of reacting HCl and NH4OH in a test tube to form white fume NH4Cl. Teacher asks the students to explain what they observed. She told students that what they observed is a typical chemical reaction.

CLASS PRESENTATION

Step 1:

Teacher writes the topic on the board, CHEMICAL REACTION and explains chemical reaction as the transformation of reactants to products. She writes the definition on the board. She writes the chemical equation for the reaction also on the board.

Step 2:

Teacher divides the class into six (6) groups providing each group with their apparatus and different reagents. She asks them to carry out the practical on their own. She asks the students to name their reagents and attempt writing the equation for the reaction.

Step 3:

Teacher asks each group to clear their table and have brief discussion among themselves on what happened during the practical session. She gives time for questions from the students as she throws the question back to the class for contribution. She acknowledges right answers and gives correction where needed. She asks the class what will happen if one of the reactants is removed or replaced with another.

Evaluation:

Teacher asks the students the following questions:

1. Define chemical reaction

2. Mention any chemical reaction and its product

3. Write chemical equation of the reaction mentioned.

Conclusion:

Teacher refreshes minds of the students on the topic of the lesson and ends the class.

LABORATORYMETHOD LESSON PLAN 2

Time: **80minutes**

Class: **SS2**

Subject: **Chemistry**

Topic: **Chemical Reaction**

Instructional Materials:

Reagents like HCl, CuSO4, NH4OH, stop watch, source of heat, test tubes beakers.

Instructional Objectives:

At the end of the lesson, students will be able to explain

1. The reaction time

2. The rate of chemical reaction

Entry Behaviour:

Students have learnt about chemical reaction. They can identify the reactants and the products from a chemical equation.

Introduction:

Students still maintaining their groups are presented with powdered and lump of CaCO3, dil H2SO4 and stop watch. They are asked by teacher to put some quantity of powdered CaCO3 and lump in separate test tubes and pour acid in each test tube.

CLASS PRESENTATION:

Step 1

Teacher explains that rate of chemical reaction is the amount of reactant or products per unit time. Teacher gives each group students two reaction set up and asks students to

determine the reaction time of the two reactions and also to define the rate of chemical reaction according to their observations. The students interacts among themselves what happened in the two reactions that took place.

Step 2:

Working in groups the students discussed what they observed during the practical session, they observed that there is a difference in time of reaction between the test tubes. They hypothesized what caused the difference in the change of chemical reaction.

Step 3:

Teacher explains that the difference in the rate of chemical reaction is because the reaction time of the two reactions are different. The teacher asks each group to state their reaction time and defend why there is difference in reaction time. She takes questions from students and answers them.

Evaluation:

Teacher asks the students to define reaction time. She also asks them to explain the rate of chemical reaction.

Conclusion:

The teacher refreshes students' mind on what was by asking them questions gives students take home assignments.

LABORATORYMETHOD LESSON PLAN 3

Time: **80minutes**

Class: **SS2**

Subject: **Chemistry**

Topic: **Factors Affecting Rate of Chemical Reaction**

Instructional Materials:

Reagents like HCl, CaCO3, CuSO4, stop watch, source of heat, test tubes beakers.

Instructional Objectives:

At the end of the lesson, students will be able to mention and explain the factors affecting rate of chemical reaction.

Entry Behaviour:

The students have known about the rate of chemical reaction

Introduction:

Teacher asks students to observe her as she carries out these experiments. She times the reaction to get their reaction rates. These are;

* put some quantity of CuSO4 in two test tubes, heat test tube and expose the other under the sun

* into two test tubes add CaCo3, to one add dil. HCl while the other add conc. HCl.

Teacher explains that variables that bring about change in the rate of chemical reaction is known as factors affecting rate of chemical reaction.

Step 1:

She asks students to carry out their experiment. Students observed that there is a difference between heated CuSO4 and exposed CuSO4. They also observed that Conc. HCl react faster than dil. HCl. They discuss among themselves why the rate of chemical reaction of same chemical substances differs and write down their observations.

Step 2:

Teacher asks each group to explain what they observed. The teacher explained that the temperature change and the concentration of the reactants determine the chemical rate of a reaction. She calls them factors affecting the rate of the chemical reaction.

Step 3:

Teacher explains further by illustrating other factors of rate of chemical reaction. One after another she mentioned and illustrates the following; surface area of the reactants, catalyst. Teacher asks students to write factors affecting rate of chemical reaction they learnt. She goes round to check individual notes.

Evaluation:

Teacher asks students to mention the factors that affect the rate of chemical reaction. She asks them to explain each of them.

Conclusion:

Teacher touches the points discussed in the lesson. She encourages students to observe their environment to internalize the topic taught.

LABORATORY METHODS LESSON PLAN 4

Time: **80Minutes**

Class: **SS2**

Subject: **Chemistry**

Topic: **Identification of Ions**

Instructional Materials:

NaOH, salts, beakers, NH4OH, test tubes

Instructional Objectives:

At the end of the lesson, students will be able to identify cations present in a given salt

Entry Behaviour:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

Introduction:

Teacher presents to the students different salt samples. She asks them if they can identify the individual ions of the given salt. She told the students that by identifying the ions of a salt, the name of the salt is known.

CLASS PRESENTATION:

Step 1:

Teacher starting with the identification of cations, explains that cations are the positive ions like Ca2+, Na+, Al3+ etc. She told the students that common reagents for identifying cations are ammonium hydroxide (NH4OH) and sodium hydroxide (NaOH). She writes on the board the characteristics of common cations when they react with the stated reagents.

Step2:

The teacher places the reagents at strategic places in the laboratory. She asks students still maintaining their groups to

1. Feel the texture of given sample and record
2. Put small quantities of their salt sample in a test tube, add little water observe whether the salt is soluble or not and record.
3. Add in drops and in excess, observe and record changes both in drops and in excess.

Step 3:

Students discuss among their group members characteristics exhibited by the ion and from the characteristics already given in the beginning name the cation present in the salt compound. The teacher discusses with the students, makes correction where necessary.

Evaluation:

Teacher asks students to mention reagents needed for the identification of cations. She also asks them to explain characteristics of some cations.

Conclusion:

Teacher gives run down of what was taught and ends the lesson.

LABORATORYMETHOD LESSON PLAN 5

Time: **80minutes**

Class: **SS2**

Subject: **Chemistry**

Topic: **Identification of Ions**

Instructional Materials:

HCl, salts, beakers, NH4OH, test tubes

Instructional Objectives:

At the end of the lesson, students will be able to identify anions present in a given salt

Entry Behaviour:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

Introduction:

Continuing from the last lesson, teacher asks the student if the knowledge of cation only can predict name of a salt compound. She explains that identifying anion is also necessary for a salt to be named.

CLASS PRESENTATION:

Step 1:

Teacher explains that anions are negative ions such as H-, Cl-, SO32- and can be identified through the odour of their gases. She also gives odour of common gases and the characteristics of others that cannot be identified by their gases when they react with certain reagents.

Step 2:

Teacher gives students their group samples. She asks the students to add a small quantity of the sample in a test and heat gently, observe odour of the gas and record.

To another sample the teacher asks students to dissolve small quantity in water, filter and add specific reagents. They record their processes and observations.

Students among their groups check their observations with the characteristics of anions already given by the teacher and determine the anion present.

Step 3:

Teacher explains to the students areas they find difficult while she discusses with them the outcome of their practical. She further explains that by determining both the cation and anion in a compound the compound can easily be named e.g. if the cation is Ca^{2+} and anion CO_3^{2-}, the compound will be $CaCO_3$.

Evaluation:

Teacher asks students to give characteristics of some common anions. She calls out few students and asks them to identify some gases through their odour.

Conclusion:

Teacher summarizes the lesson. She gives students a salt sample to identify as an assignment.

LECTURE METHOD LESSON PLAN 1

Time: 80 minutes

Class: SS2

Subject: Chemistry

Topic: Chemical Reaction

Instructional Materials:

Teacher's note book

Instructional Objectives:

At the end of the lesson, the students will be able to

1. Name the reactants and products of a given chemical reaction

2. Write a balanced equation of the reaction.

Entry Behaviour:

Students have learnt names of common reagents in the laboratory

Introduction:

Teacher asks students to mention different reagents found in the laboratory. She explains that when two or more substances come together reaction takes place. She writes on the board chemical reaction as the topic of the day.

CLASS PRESENTATION:

Step 1:

Teacher writes the topic on the board, CHEMICAL REACTION and explains chemical reaction as the transformation of reactants to products. She writes the definition on the board. She writes the chemical equation for the reaction also on the board.

Step 2:

Teacher gives some of the examples of chemical equation and writes the equation on the board. She writes short note about examples of chemical reactions and asks students to copy them in their note books.

Step 3:

Teacher explains that chemical reaction can be in many forms such as neutralization reaction, dissociation reaction, redox reaction, decomposition reaction etc. she explains each of the reactions and writes short note on this for the students to copy.

Evaluation:

Teacher asks the students the following questions:

1. Define chemical reaction

2. Mention any chemical reaction and its product

3. Write chemical equation of the reaction mentioned.

Conclusion:

Teacher refreshes minds of the students on the topic of the lesson and ends the class.

LECTURE METHOD LESSON PLAN 2

Time: 80 minutes

Class: SS 2

Subject: Chemistry

Topic: Rate of Chemical Reaction

Instructional Materials:

Teacher's note book

Instructional Objectives:

At the end of the lesson, students will be able to explain

1. the reaction time

2. the rate of chemical reaction

Entry Behaviour:

Students have learnt about chemical reaction. They can identify the reactants and the products from a chemical equation.

Introduction:

Teacher asks students questions based on what studied previously. She explains to the chemical reaction of some substances are slow while others are fast. She terms it rate of chemical reaction.

CLASS PRESENTATION:

Step 1:

Teacher explains that rate of chemical reaction is the amount of reactant or products per unit time. She gives examples of reactions when they are fast and slow eg CaCO3 reacts faster when it is in powdered form than when in lump. She copies note on the board for the students.

Steps 2:

Students copy note and ask questions if any.

Step 3:

Teacher explains that the difference in the rate of chemical reaction is because the reaction time of the two reactions are different. The teacher asks students to explain why there is difference in reaction time even when the substances used are same. She takes questions from students and answers them.

Evaluation:

Teacher asks the students to define reaction time. She also asks them to explain the rate of chemical reaction.

Conclusion:

The teacher refreshes students' mind on what was by asking them questions gives students take home assignments.

LECTURE METHOD LESSON PLAN 3

TIME: **40Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Factors Affecting Rate of Chemical Reaction**

INSTRUCTIONAL MATERIALS:

Teacher's note

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to mention and explain the factors affecting rate of chemical reaction.

ENTRY BEHAVIOUR:

The students have known about the rate of chemical reaction

INTRODUCTION:

Teacher refreshes students' on what they did in last their rate of chemical reaction. She explains that time taken for a reaction to take place is being determined by different variables called factors affecting rate of chemical reaction.

CLASS PRESENTATION:

Step 1

The teacher writes the topic on the board. She takes the factors one after another, explains and writes the explanation on the board for the students to copy.

Step 2

Students ask teacher questions for further explanations. Teacher also explains other factors affecting rate of chemical reaction. She writes out the factors and their explanations on the board and students copy.

Evaluation:

Teacher asks students to mention the factors that affect the rate of chemical reaction. She asks them to explain each of them.

Conclusion:

Teacher touches the points discussed in the lesson. She encourages students to read their text books and ask questions where they get confused.

LECTURE METHOD LESSON PLAN 4

TIME: **40Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Identification of Ions**

INSTRUCTIONAL MATERIALS:

Teacher's note

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to identify cations present in a given salt

ENTRY BEHAVIOUR:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

INTRODUCTION:

Teacher asks students following questions:

1. Define an ionic compound

2. What are the characteristics properties of ionic compound?

Teacher tells the students that the ionizing property of ionic compounds makes it possible for their ions be identified.

CLASS PRESENTATION:

Step 1:

Teacher starting with the identification of cations, explains that cations are the positive ions like Ca2+, Na+, Al3+ etc. She told the students that common reagents for identifying cations are ammonium hydroxide (NH4OH) and sodium hydroxide (NaOH). She writes on the board the characteristics of common cations when they react with the stated reagents.

Step2

Students take down the notes on the identification of cations. They ask questions and also answer teacher's questions.

Evaluation:

Teacher asks students to mention reagents needed for the identification of cations. She also asks them to explain characteristics of some cations.

Conclusion

Teacher gives run down of what was taught and ends the lesson.

LECTURE METHOD LESSON PLAN 5

TIME: **40Minutes**

CLASS: **SS2**

SUBJECT: **Chemistry**

TOPIC: **Identification of Ions**

INSTRUCTIONAL MATERIALS:

Teacher's notebook

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students will be able to identify anions present in a given salt

ENTRY BEHAVIOUR:

The students have learnt about the ionic compounds as compounds (salts) that contain both cation and anion.

INTRODUCTION:

Continuing from the last lesson, teacher asks the student if the knowledge of cation only can predict name of a salt compound. She explains that identifying anion is also necessary for a salt to be named.

CLASS PRESENTATION:

Step 1

Teacher explains that anions are negative ions such as H-, Cl-, SO32- and can be identified through the odour of their gases. She also gives odour of common gases and the characteristics of others that cannot be identified by their gases when they react with certain reagents.

Step 2

Students copy their notes. Teacher gives students time to ask her questions. She answers their questions and also ask them questions

Evaluation:

Teacher asks students to give characteristics of some common anions. She mentions some characteristics of some gases and ask students to identify the gas.

Conclusion:

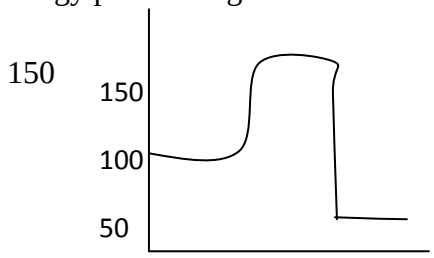
Teacher summarizes the lesson and gives them assignment.

APPENDIX II

CHEMISTRY ACHIEVEMENT TESTS

1. Which of these does not affect the rate of chemical reaction?
   A. Concentration of the reactants B. addition of a catalyst C. Size of the reacting particlesD. the enthalpy change for the reaction
2. What quantity of silver is deposited when 96500C of electricity is passed through a solution containing silver ions?(Ag =108, 1F = 96500C)
   A. 108g B. 5.40g C. .8gD. 21.6g
3. During the electrolysis of dilute tetraoxosulphate (VI) acid solution, 0.05 mole of electrons were passed. What volume of gas was produced at the anode? (Volume of gas at S.T.P = 22.4dm^3).
   A. 0.224dm^3 B. 0.280dm^3 C. 0.560dm^3 2.24dm^3
4. What quantity of copper will be deposited by the same quantity of electricity that deposited 9.0g of aluminium?
   A. 64gB. 32gC.7.1g D. 6.4g
5. When ammonium chloride is dissolved in water in a test tube, the test tube feels colder showing that
   A. The solution is unsaturated B. sublimation has occurred C. ammonia gas is evolvedD. the process is endothermic
6. Which of the following will increase the rate of reaction of chips of a metal M as shown in the equation below? M + 2HCl → MCl + H_2
   A. Diluting the hydrochloric acid B. Adding some distilled waterC. Decreasing the temperatureD. Grinding the metal into powder
7. Which of the following occurs when aqueous solution of sodium hydroxide is electrolyzed using graphite electrodes?
   A. Sodium metal is produced at the anode B. Sodium amalgam is formed at the cathode C. Oxygen gas is produced at the anodeD. The graphite anode dissolves.
8. How many faradays of electricity are required to liberate 9g of aluminium? (Al = 27)
   A. 0.1 B. 0.3 C. 1.0 D. 2.7
9. Which of the following is not correct about a catalyst?
   A. Remains unchanged chemically at the end of a reaction B. helps to establish equilibrium faster in reversible reaction C. Can start a chemical reaction which will normally not take place D. is usually specific in its action
10. What amount of copper is deposited when 13.0g of zinc reacts with excess copper (II) tetraoxosulphate (VI) solution according to the following equation?
    $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$
    [Cu = 63.5, Zn = 65]
    A. 0.1mole B. 0.2m0le C. 0.3m0le D. 0.4mole

11. Which of the following ions will migrate to the cathode during electrolysis?
    A. Zinc ions B. Chloride ionsC. Sulphide ionsD. Tetraoxosulphate (VI) ions
12. The position of equilibrium in a reversible reaction is affected by
    A. Particle size of the reactants B. change in concentration of the reactants C. change in size of the reaction vessel D. presence of a catalyst
13. Which of the following produces oxygen and hydrogen during its electrolysis using platinum electrode?
    A. A Glucose solution B. Aqueous copper (II) tetraoxosulphate (VI) C. Dilute sodium chloride solution D. Concentrated hydrochloric acid
14. What mass of copper would be deposited by a current of 1.0 ampere passing for 965 seconds through copper (II) tetraoxosulphate (VI) solution? [Cu = 63.5, 1F = 96500C]
    A. 0.318gB. 0.635g C. 3.18gD. 6.35g
15. What is the value of heat change for the reaction represented by the following energy profile diagram?



    A. -50kJ/mol B. -100kJ/mol C. 100kJ/molD. 150kJ/mol

16. An exothermic reaction is one which involves

    A. attainment of dynamic equilibrium B. loss of heat to the surrounding C. evolution of gas as it proceeds D. positive change in value of enthalpy.

17. Which of the following lowers the activation energy of a chemical reaction?

    A. Freezing mixture B. Reducing agent C. Water D. Catalyst

18. Consider the reaction represented by the following equation: $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$. The number of effective collisions of molecules of the reactant decreases as

    A. the temperature is raised B. the pressure is increased C. the volume is increased D. the reaction will go to completion

19. What will be the effect of increase in pressure of the following system at equilibrium?

$$2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)}$$

A. Activation energy will decrease B. The forward reaction will be favouredC. The concentration of ammonia will increaseD. The reaction will go to completion.

20. Chemical equilibrium is attained when

A. reactants in the system are used up.B. concentration of the products is greater than those of the reactants. C. concentrations of thereactants and products remain constant. D. reactants stop forming the products

21. Which of the following occurs when a solution of $CuSO_4$ is electrolysed using copper electrodes?

A. the cathode becomes coated with copper. B. both electrodes gain electrons C. the blue colourof copper fades gradually.D. the anode increases in mass.

22. A concentrated solution containing H^+, Cu^{2+}, OH^- and Cl^- waseletrolysed using platinum electrodes. Which of the ions will be discharged at the cathode?

A. H^+ B. Cu^{2+}C. OH^-D. Cl^-

23 A reaction is represented by this equation:$A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$; ΔH =

-363kJ/mol. Which of the following statements about the system is correct?

A. The forward reaction is exothermic B. The reaction goes to completion at equilibrium

C. Pressure has no effect on the equilibrium mixture D. At equilibrium, increase in temperature favours the reverse reaction.

24. In the electrolysis of $CuSO_4$ solution using copper electrodes, the reaction at the anode is

A. Discharge of SO_4^{2-} B. discharge of OH^- C. dissolution of copper electrode

D. evolution of oxygen

25. What will happen if more heat is applied to the following system at equilibrium?

$X_{2(g)} + 3XY_{3(g)} \rightleftharpoons 2XY_3$; $\Delta H = -x$kJ/mol

A. The yield of XY_3 will increaseB. More of XY_3 will decomposeC. More of X_2 will react D. The forward reaction will go to completion.

26. What are the values of x,y,z respectively in the following reaction?

$MnO_{2(s)} + xHCl_{(aq)} \rightarrow MnCl_{(aq)} + yH_2O_{(l)} + zCl_{2(g)}$

A. 4,1,2 B. 1,2,1 C. 2,12 D. 4,2,1

27. Two solutions containing Pb^{2+} and Al^{3+} respectively can be distinguished using

A. $NaOH_{(aq)}$ B. $NH_{3(aq)}$ C. Conc HNO_3D. Conc. HCis added to l

28. When ammonium trioxocarbonate (IV) solution is added to separate solutions of calcium,

Zinc and sodium salts precipitate could be formed in the case of

A. Calcium only B. Zinc only C. Calcium and zinc only D. sodium and zinc only

29. Which of the following pairs of acids and bases will produce a solution with pH less than 7 atequivalence point?

A. HNO_3 and NaOH B. H_2SO_4 and KOH C. HCl and $Mg(OH)_2$ D. HNO_3 and KOH

30. Which of the following gases is colourless, odourless and soluble in potassium hydroxidesolution?

A. NO_2 B. SO_2 C. NH_3 D. CO_2