# EFFECTS OF CONCEPTUAL CHANGE INSTRUCTIONAL STRATEGY FOR REMEDIATING MISCONCEPTIONS IN ACIDS AND BASES CONCEPTS AMONG CHEMISTRY STUDENTS OF ZARIA EDUCATION-ZONE KADUNA-NIGERIA

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**ZARIA, NIGERIA**

**NOVEMBER, 2019**

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY ZARIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN SCIENCE EDUCATION**


**DEPARTMENT OF SCIENCE EDUCATION,**
**FACULTY OF EDUCATION,**
**AHMADU BELLO UNIVERSITY,**
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**NOVEMBER, 2019**

# DECLARATION

I declare that this dissertation entitled “Effects of Conceptual Change Instructional Strategy for Remediating Misconceptions in Acids and Bases Concepts among Chemistry Students of Zaria Education-zone, Kaduna-Nigeria” was carried out by me Swafiyah BAWA (P16EDSC8303) in the Department of Science Education, Faculty of Education, Ahmadu Bello University Zaria. The information derived from Literature has been duly acknowledged in the text and list of references provided. No part of this work has previously been presented for another Degree or Diploma at this or any other institution.

______________________ ______________________

Swafiyah BAWA Date

## CERTIFICATION

This dissertation entitled: "Effects of Conceptual Change Instructional Strategy for Remediating Misconceptions in Acids and Bases Concepts Among Chemistry Students of Zaria Education-Zone Kaduna, Nigeria" written by Swafiyah BAWA (P16EDSC8303) meets the regulations governing the award of Masters Degree in Science Education of Ahmadu Bello University Zaria and is approved for its contribution to knowledge and literary presentation.

__________________________ ___________________

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Dean, School of Postgraduate Studies

# DEDICATION

This research work is dedicated to my late father Prof. M.S. Bawa.

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# ABBREVIATIONS

The following abbreviations were used in this study. They include:

**ABMT:** Acids and Bases Misconception Test

**ABPT:** Acids and Bases Performance Test

**CCIS:** Conceptual Change Instructional Strategy

**NPE:** National Policy on Education

**SSCE:** Secondary School Certificate Examination

**SSSCE:** Senior Secondary School Certificate Examination

**SS I**: Senior Secondary I

**WAEC:** West Africa Examination Council

## OPERATIONAL DEFINITION OF TERMS

The following terms are operationally defined as used in the study:

**Conception:** These are the initial perception of ideas, experiences, and knowledge students have formally acquired about the concepts being taught before exposure to new instructions in question.

**Conceptual Change:** This entails a shift of idea, deeper understanding or categorical change from the previous knowledge/experience on a concept to the new scientifically valid conception.

**Conceptual Change Instructional Strategy:** An instructional strategy in which the teacher acts as a facilitator, providing thought provoking questions, experiments and guiding discussions which will lead students' thinking towards constructing scientifically valid ideas. Through the students teaching become more able to recognize, evaluate and decide whether to reconstruct existing ideas and beliefs relevant to the topic in question.

**Misconception:** Refers to individual's pre-existing wrong notions of facts, which constitutes a reliable aspect of his/her theoretical knowledge, but judged by experts in the field to be at odd with the scientifically or commonly accepted scientific ideas.

**Performance:** Refers to what you get out of an activity carried out by students for what they put in.

**Remediation:** A solution intended to correct wrong notion i.e putting wrong notions right.

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**ABSTRACT**

This study investigated the Effects of Conceptual Change Instructional Strategy for Remediating Misconceptions in Acid-Base Concepts among Chemistry Students of Zaria Education-Zone Kaduna, Nigeria. Quasi – experimental design was used for the study. The population of the study comprised of 21 schools out of which 14 were co-educational and 7 were single-sex schools. A total of 1434 SS I chemistry students in Zaria Education-Zone formed the population. Random sampling was used to select the sample for the study after establishing their equivalence using pretest. The sample of the study comprised of 110 students out of which 65 were males and 45 were females. Two instruments; Acids and Bases Misconception Test (ABMT) and Acids and Bases Performance Test (ABPT) with reliability coefficient of 0.68 and 0.78 respectively were used to collect the data for the study. Five research questions and four hypotheses were stated and tested at $p \leq 0.05$ level of significance using t-test statistic. Major findings from the study were: four types of misconceptions were identified among SSI chemistry students. Chemistry students taught using conceptual change instructional strategy performed significantly better than those taught using lecture method. Based on the findings, it was recommended that, workshops and seminars should be organized for Chemistry Teachers of Secondary Schools on the use of Conceptual Change Instructional Strategy for the teaching and learning of chemistry to help shift unscientific ideas students hold to scientifically valid ideas.

# CHAPTER ONE

# THE PROBLEM

## 1.1 Introduction

Science is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe. Science educators like Gabel (2003),Chin and Chai (2005) have been advocating the need for science instruction at all levels to focus on enhancing students conceptual understanding, higher levels of performance in scientific thinking, reasoning and problem solving. This advocacy is inconsistent with various reform initiatives around the globe, for science, mathematics curricula and classroom practices. Alake (2015) posited that, the main objective of learning science is to provide a systematic, practical and interdisciplinary overview of the discipline and to change student behavior through this knowledge. Science uses observation and inferences as fundamental tools for inquiry. Earl, (2000) defined science as the knowledge within the limits of perception of individuals. Through science, people achieve greater understanding of their environment.

Chemistry is one of the science subject taught at the Senior Secondary Certificate Examination (SSCE) level in Nigerian schools, it is an experimental science which relies primarily on the harmony between theory and practical and is expected to be taught as such. Njoku (2005), claimed that chemistry is often regarded as a difficult subject, an observation which sometimes repels learners from continuing with studies in chemistry. Sherma and Sherma (2004), defined chemistry as the science that describes the structure and composition of the universe, the changes in structure and composition these materials undergo and the energy relation involved in these changes. Chemistry is characterized and studied at secondary and tertiary levels under its varying branches; organic, inorganic, physical, analytical, industrial and nuclear among others. Chemistry is a very important subject as its knowledge is required for the successful practice in professions like medicine, engineering, biochemistry among others. Due to its importance, chemistry is occupying an important place in the senior secondary school curriculum. It is one of the core subjects that all science students must offer.

Njoku, (2005) and West Africa Examination Council (WAEC) Chief Examiner Report 2010-2014 stressed that in spite of the central and important position of chemistry among other science subjects, achievement of students in chemistry at Senior Secondary School Certificate Examination (SSSCE) has consistently been very poor and unimpressive. Researchers like Onder and Geban (2006); Abuzer (2009), Tami, Avi, Racheal and Ziva (2014) identified the factors that contribute to poor performance of students in chemistry to include, students misconceptions, the abstract and difficult nature of the subject, inadequate laboratory infrastructure and equipment for teaching the subject. Eniayeju, (2001), suggested poor teaching methods, students' misconceptions, lack of adequate practical equipment, mathematical nature of chemistry concepts and laws among others.

Onwu (2002) advocated that research in chemistry education has continue to seek for better approaches for teaching chemistry in order to bring about identifying factors responsible for low conceptual understanding in chemistry among secondary school students. Muhammad (2007) and Bugaje (2010) confirmed that most concepts in chemistry are abstract, therefore there is the need to employ teaching strategies that will make easy the understanding of concepts been taught. Harizal (2012), further stated that in chemistry, acids and bases concepts occupies a central place since it involves both theory and practical aspect and in most of the chemical reactions, acid-base reactions usually takes place. Muhammad (2014) confirmed that the acids and bases concept are considered as one of the difficult and abstract topics to students. Chemistry is a science subject that has a number of abstract concepts that can be interpreted and learned wrongly by the students. The fact that students cannot view what is happening at molecular level makes the interpretation of the chemical phenomena even more abstract and so difficult. Bhimand Aniruddha (2013) described acids and bases concepts as an abstract topic where students have difficulties. However, acids and bases concept requires understanding the concept of atoms at molecular level and their properties. Ababio (2005) stressed that acids and bases are classified by the ions that are formed when they are added to water. Acids are compounds that produce hydrogen ions (H+) in solution. Bases are compounds that produce hydroxide ions in (OH-) solution. Acids and bases can be identified by their properties. Acids taste sour and turn litmus paper red. Bases feel slippery, taste bitter, and turn litmus paper blue.

Njoku, (2005), observed that the failure rate of students in chemistry is due to the misconceptions held by them. These misconceptions could arise from the abstract nature of some of the concepts. Nurmi and Jaakola (2008) and Treagust and Duit (2008) defined misconceptions as stable cognitive structures that affect learners' understanding of scientific concept; they are highly resistant to change. Elsewhere, Lawal (2009), perceived misconceptions as students' incorrect pattern of response, informal ideas, non-scientific interpretations and conceptions leading to conflict with scientific views. According to Eryılmaz (2002), Engelhardt and Beichner, (2004), these misconceptions can also be referred to as "preconceptions". Ezenwa (1993) categorized misconceptions into preconceived notions, nonscientific beliefs, conceptual misunderstanding etc. these categories of misconceptions needed extra effort on the part of the teacher to effect any correction in the learner. Kikas, (2004) explained that this different or "unaccepted" scientific view of the learner have been variously labeled by different researchers as alternative conceptions, preconceptions, mini theories, misconception, faulty conceptions etc.

Duit and Treagust (2008), revealed that many cases of misconceptions are strongly resistant to traditional teaching. Thus it is necessary to establish a teaching strategy which is highly applicable to school education curricula and effective in correcting misconception, and in which most students are interested. Research findings of Olorukooba, (2001) however, revealed that to date, a large proportion of science teachers, chemistry inclusive, still resort to the use of traditional lecture method rather than the activity oriented strategies like demonstration, discussion, experimentation etc. According to Gobinath (2001), Okebukola (2002) and Palmer (2002), a number of science education researchers have been concerned with developing ways of facilitating students' understanding of science. Vosniadou (2007), Treagust and Duit (2008), advocated that to promote conceptual understanding and eliminate learners' misconceptions, various conceptual change strategies for teaching and learning approaches is necessary. Lawal (2009), defined conceptual change instructional strategy as an instructional strategy in which the teacher acts as facilitator providing thought provoking questions experiments and guided discussion which helps to lead students to think towards constructing scientific valid ideas.

However, there are various instructional strategy used to overcome misconceptions for better understanding and meaningful learning. Some of these includes conceptual change model developed by Posner et al.(1982), conceptual change models by Osborne and Cosgrove (1985), Driver (1980) and Roth (1985) among others. The model of Posner et al.(1982) described four necessary conditions (dissatisfaction, intelligibility, plausibility and fruitfulness). Some of the misconceptions students possess among others are associated with difficulties in comprehending the concepts of acids and bases as complementary reactions, difficulties in identifying acidic and basic substances; imprecise terminology and complex language use.

Considerable amount of research focused on gender differences in school science learning. Abduraheem (2012) reported that one of the most tropical issues in the debate all over the world has been gender differences and academic performance among students in schools. However, the influence of gender on students' performance in science has for a long time been of concern to many researchers to date, no consistent result has been established. For instance, Avwiri and Nbina (2014) and Muhammad, (2014) reported that gender has no influence on students' achievement in science. Omwirhiren (2013) and Daluba (2013) noted that the male perform significantly better than their female counterparts in evaluating science concepts. Ishaya, (2013) explained that female subject were significantly better than their male counterparts and that there was a significant difference between male and female subjects in their ability to solve quantitative problems. Some instructional strategies like cooperative learning, demonstration are gender-bias Olorokooba (2001), while some like conceptual instruction, cooperative teaching strategy are gender friendly Muhammad (2014). However, the degree of gender-related differences in learning varies from one method of instruction to the other. Gender differences are therefore another factor to be investigated in this study in relation to conceptual change and academic performance in acids and bases concepts.

### 1.1.1 Theoretical Framework

The theoretical framework of this work was based on Ausubel's theory of learning. The theory attempts to give explanation to how meaningful learning is achieved. Ausubel (1960) proposed a cognitive theory of learning which dealt with what he exclusively called meaningful learning. According to Ausubel (1968), meaningful learning occurs only when the learner has mental representation of an object or concept to be learnt. In other words meaningful learning takes place only when the learners' prior knowledge is related to the new materials to be learnt must carefully be linked to the learners' prior knowledge. Where such prior knowledge is not related to the new materials to be learnt and cognitive structure fails, the learner results to rote learning as an alternative. Ausubel called the learners cognitive structure that is necessary for meaningful learning subsumers. The subsumer is seen as a general principle or a generalized body of knowledge that learner already acquired. It is such knowledge that provides for association or anchorage for the various component of new knowledge. Ausubel believed that to effect a change in the erroneous ideas of the learner prior knowledge of the learner must be considered.

Learners construct their own knowledge as a result of their interaction with specific phenomena. Such conceptions which are formed by the learners during the process of learning contribute to personal explanation of the knowledge in question. It is such concepts that are referred to as prior knowledge hence form the basis upon which new knowledge is built in the school/learning situation. As such the learner gets meaningful learning by bringing appropriate existing conceptions to bear on new situations. Good *et al.*, cited in Lawal (2009), observed that the construction of new knowledge goes more smoothly when learners can relate new content to their existing background of knowledge. In the current study, a modified classical conceptual change instructional approach, suggested by Posner et al.(1982) was used for this study because, the model helps learners in transforming preconceptions which could be wrong into scientific conceptions and it appears logically and comprehensively when presented as compared to other models.

## 1.2 Statement of the Problem

Studies have shown that Nigerian students have for many decades performed poorly in chemistry at Senior Secondary School Certificate Examination (SSSCE) level (Njoku, & Eze-Odurunkwe,2014; Muhammad 2014). Students' persistent mass failure has been attributed to a number of factors among which are misconceptions students hold, some chemistry concepts which research identified to be difficult for student to learn, these include: heat capacities, latent-heat and heat changes, systems (open, closed and isolated) works, isobaric, isothermal, isochoric, nuclear reactions, equilibrium reactions, chemical energetic, oxidation-reduction reactions and the concepts of acids and bases among others (Echekwube 2009, Chief Examiners Council WAEC 2013,2014,2015 & 2016). The performances of students in chemistry in Nigeria have been consistently poor over the years. Table 1.1 describes the performance of students in chemistry from 2013-2017

**Table 1.1: Performance of Students in Chemistry at SSCE Level (WAEC) in Nigeria 2010-2014**

| Year | No. of registered Students | No. of Students that sat | % passes at credit level ($A_1 – C_6$) | % Failure ($D_7 – F_9$) |
|---|---|---|---|---|
| 2013 | 477,573 | 465,643 | 50.72 | 49.28 |
| 2014 | 575,757 | 565,692 | 49.54 | 50.46 |
| 2015 | 641,622 | 627,302 | 43.13 | 56.87 |
| 2016 | 623,543 | 593,344 | 45.76 | 54.24 |
| 2017 | 705,334 | 689,534 | 43.42 | 56.58 |

Source: (WAEC Chief Examiner's Report 2013-2017)

Table 1.1 shows that from 2013-2017, the number of students' failure is above average compare to 2010 performance which is lower. More so, De Jong and Treagust (2002), Österlund and Ekborg (2009), confirmed that the concepts of acids and bases are perceived to be one of the most difficult areas both to learn and to teach. It could be deduced that chemistry students are facing difficulties in the learning of the subject which has resulted in the consistently poor performance over the years.

Lawal (2009), expressed that a number of science research has been carried out by several science educators, revealing different types of misconceptions, its causes and effects among science students. However, very few went ahead to proffer ways in which the misconceptions might best be changed .Thus the question of how students can be encouraged to give up their previously acquired misconceptions is still a pedagogical problem. Mulhall, McKittrick and Gunstone (2001), confirmed that students' understanding of key concepts related to science topics has been an interesting research area and it has been investigated by researchers in chemistry education. However, Jaakkola and Nurmi(2008), Treagust and Duit (2008) agreed that students come to the classroom with a range of informal ideas and most of them are different from scientific conceptions. Gilbert (2006), described a list of problems that challenge the teaching of chemistry. Amongst these are the students' difficulties with solving problems where the same concept is used but in different contexts. However, Geban (2012), claimed that misconceptions cannot be remediated by traditional instruction. Therefore, the study investigated how students change their alternative conceptions to scientific concepts using conceptual change instructional strategy.

## 1.3 Objectives of the Study

The following objectives are stated for the study to:

1. Identify and classify the types of acids and bases misconceptions held by SS I chemistry students.
2. Determine the difference in the misconception mean scores in the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method.

3. Determine the difference in the misconception mean scores in acids and bases concept of male and female students taught using CCIS and those taught using lecture method.
4. Find out whether there is any difference between the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction.
5. Determine the academic performance of male and female chemistry student taught using conceptual change instructional strategy.

## 1.4 Research Questions

In line with the objectives stated, the investigation focused on finding answers to the following research questions:

1. What are the types of acids and bases misconceptions held by SS I chemistry students?
2. What is the difference in the misconception mean scores of the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method?
3. What is the difference in the misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method?
4. What is the difference between the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction?
5. What is the difference in academic performance of male and female chemistry students taught using conceptual change instructional strategy?

## 1.5 Research Hypotheses

The following hypotheses are formulated for testing at $p \leq 0.05$ level of significance.

$HO_1$: There is no significant difference in the misconception mean scores in the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method.

$HO_2$: There is no significant difference in the misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method.

$HO_3$: There is no significant difference between the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction.

$HO_4$: There is no significant difference in academic performance of male and female chemistry students taught using conceptual change instructional strategy.

## 1.6 Significance of the Study

The findings of this study would hopefully uplift the standard of chemistry education in the following ways:

**Students:** The students will benefit more from the finding of the study, as it will hopefully help them improve their understanding of the identified misconceived and related concepts in acids and bases. Hence, improve their academic performance and be able to learn effectively. The institutions of higher learning where chemistry students are trained would make use of conceptual change instructional strategy so as to equip the students re-construct knowledge on their own.

**Teachers:** It will provide teachers- in- training with knowledge on other strategies that can be used to teach acids and bases concepts in the classroom example conceptual change instructional strategy. It will help teachers in finding out the types of misconceptions SSI students hold about acids and bases concepts.

**Professional Bodies:** The study is expected to be beneficial to professional organizations such as National Teachers Institute (NTI), Science Teachers Association of Nigeria (STAN), National Educational Research and Development Council (NERDC), among others, that carry out researches and organize conferences, seminars, and workshops for practicing science teachers on how conceptual change instructional strategy could be effectively used to promote the teaching and learning in schools. Textbooks publishers and researchers may find this study very useful in their presentation and publications of the subject – matter as a form that would facilitate easier understanding of concepts i.e. remediating misconceptions of concept held by chemistry students, particularly in acids and bases.

**Researchers:** Researchers will find the result of this study useful in the sense that this study is a foundation for further studies in chemistry and it will add new knowledge to the existing literature.

## 1.7 Scope of the Study

The population of the study comprised of public senior secondary schools within Zaria which are 21 in number and comprising of 1434 students. A total of seven (7) schools were randomly selected comprising of 578 students. The subject in the study were SS I chemistry students of Zaria Education-zone because the concept was taught at this level. SS II were not used for the study because they have covered that aspect of the syllabus in their year 1 while SS III students are preparing for their SSCE examination and most of the students might not give the researcher the required attention. Acids and bases concepts were chosen due to the mass failure of students and mostly students have misconceptions regarding the concept Muhammad, (2007) and (WAEC, Chief Examiner's Report, 2013).

## 1.8 Basic Assumptions

The study has the following basic assumptions:

i. The conceptual change instructional strategy is measurable on the students under study.

ii. Misconceptions held by students in chemistry can be determined.

# CHAPTER TWO

# REVIEW OF RELATED LITERATURE

## 2.1 Introduction

In this study the use of a conceptual change instructional strategy in remediating misconception in acids and bases concepts among chemistry students was investigated. In this chapter, the literature relevant to this study was reviewed and presented under the following sub-headings:

2.1 Introduction

2.2 Teaching of Chemistry at Senior Secondary School Level

2.2.1 Teaching of Acid-Base at Senior Secondary Certificate Examination Level.

2.3 Meaning of Conception and Misconception

2.3.1 Sources of Students Misconception

2.3.2 Misconceptions in Chemistry Concepts.

2.3.3 Misconception in Acid-Base Concepts.

2.4 Conceptual Change Instructional Strategy and Learning of Science

2.4.1 Teaching Models for Conceptual Change

2.4.2 Lecture Method of Teaching.

2.5 Remediation Strategies

2.6 Academic Performance of Students in Chemistry at SSCE

2.6.1 Gender and Academic Performance in Chemistry

2.7 Overview of Similar Studies on Remediating Misconceptions in Science

2.8 Implications of Literature Reviewed on the Present Study.

## 2.2 Teaching of Chemistry at Senior Secondary School Level

United Nations Education Scientific and Cultural Organization, UNESCO, (2005) described secondary school education as a critical level in any educational system. As a transactional level to higher education, it is important for economic development of a nation, socialization and empowerment of the youth who are faced with massive level of unemployment. In Nigeria's Policy on Education (FGN, 2013) divided secondary school education in two sections of three years each namely; Junior Secondary (JSI-3) and Senior Secondary (SS1-3).

Chemistry as defined by Ababio (2005) is the study of matter, what it is made of, how it behaves, its properties and how it changes during chemical reaction. Many new substances have been created through chemistry which has many important applications in our lives. In Nigeria, the sciences are taught in school subjects as Biology, Chemistry and physics. Nigerian National Policy on Education stipulated that chemistry is taught at senior secondary schools from SS1-SS3 classes.

The National Policy on Education (2013) in the National Curriculum for Secondary Schools stated specific objectives to be achieved in the chemistry curriculum which include;

a. Facilitate a transition to the use of scientific concepts and techniques acquired in integrated science with chemistry.

b. Provide the students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing.

c. Show chemistry in its interrelationship with other subjects

d. Show chemistry and its link with industry, everyday life, benefits and hazards.

e. Provide a course which is complete for pupils not proceeding to higher education while it is the same time a reasonably adequate foundation for postsecondary chemistry course.

Within the context of science education, Adamu, Boris and Kenni (2013), identified chemistry as an important course of study and its significance in scientific and technological development. It was as a result of the recognition given to chemistry in the development that it is made a core-subject in school science curriculum.

### 2.2.1 Teaching of Acids and Bases at Senior Secondary Certificate Examination Level

There are three major classifications of substances known as acids or bases or salts. The Arrhenius definition states that an acid produces $H^+$ in solution and a base produces $OH^-$. This theory was developed by Svante Arrheniusin 1883. Later, two more sophisticated and general theories were proposed. These are the Brønsted-Lowry and the Lewis definitions of acids and bases.

The Arrhenius Theory of Acids and Bases

In 1884, the Swedish chemist Svante Arrhenius proposed two specific classifications of compounds; acids and bases. When dissolved in an aqueous solution, certain ions were released into the solution. An Arrhenius acid is a compound that increases the concentration of $H^+$ ions that are present when added to water. These $H^+$ ions form the hydroxonium ion ($H_3O^+$) when they combine with water molecules. This process is represented in a chemical equation by adding $H_2O$ to the reactants side.

$$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

In this reaction, hydrochloric acid (HCl) dissociates completely into hydrogen ($H^+$) and chlorine ($Cl^-$) ions when dissolved in water, thereby releasing $H^+$ ions into solution. Formation of the hydroxonium ion equation:

$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

An Arrhenius base is a compound that increases the concentration of $OH^-$ ions that are present when added to water. The dissociation is represented by the following equation:

$NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

In this reaction, sodium hydroxide (NaOH) disassociates into sodium ($Na^+$) and hydroxide ($OH^-$) ions when dissolved in water, thereby releasing $OH^-$ ions into solution.

However, Arrhenius acids are substances which produce hydrogen ions in solution while Arrhenius bases are substances which produce hydroxide ions in solution.

The Brønsted-Lowry Definition In 1923, chemists Johannes Nicolaus Brønsted and Thomas Martin Lowry independently developed definitions of acids and bases based on the compounds' abilities to either donate or accept protons ($H^+$ ions). In this theory, acids are defined as proton donors; whereas bases are defined as proton acceptors.

The Bronsted-Lowry Theory of Acids and Bases revealed that acid is a proton (hydrogen ion) donor and base is a proton (hydrogen ion) acceptor. In this theory, an acid is a substance that can release a proton (like in the Arrhenius theory) and a base is a substance that can accept a proton. The Lewis theory of acids and bases states that acids are electron pair acceptors while bases are electron pair donors. Acids and bases can be defined by their physical and chemical observations. However, since acids increase the amount of $H^+$ ions present and bases increase the amount of $OH^-$ions, under the pH scale, the strength of acidity and basicity can be measured by its concentration of $H^+$ ions. This scale is shown by the following formula:

$pH = -\log[H^+]$ ; $[H^+]$ being the concentration of $H^+$ ions.

In accordance with the above definitions, Wikipedia, (2009) revealed that the term acid was derived from the Latin “acidus” meaning “sour” it is traditionally considered to be any chemical substances that when dissolved in water gives a solution with high concentration hydrogen ion activity greater than that of pure water i.e. a PH less than 7.0. However Wikipedia defined an acid as a compound that donates hydrogen ion (H+) in solution to another substance called base. Common examples of acids include acetic acid in vinegar and sulphuric acid used in car batteries.

Blair, (2005) defined base as a substance that accepts hydrogen ion from an acid or it is a substance that increases the concentration of hydroxyl in solution (OH-). Examples of bases include sodium hydroxide used in the manufacture of soap, sodium salt and plastics, potassium hydroxide used in the manufacture of dying and in electroplating.

The researcher intends to use conceptual change instructional strategy to teach the concept of acids and bases.

## 2.3 Meaning of Conceptions and Misconceptions

Researches conducted on conceptions and misconceptions are numerous and could be explained as follows;

### 2.3.1.1 Conceptions

Conception is the idea a learner already has about a phenomenon. Conceptions according to Piaget (1977) are formed by the individual through the process of equilibration. Sadera, (2006) confirmed that conception are ideas and understandings that have been developed over time as a result of experiences, observation, experimentation and thought. Tamer and Smith (2014) defined conception as the personal explanatory knowledge about how the things around operates. The above definitions show clearly that conceptions are individual constructs. This is in line with certain assertion related to constructivist views of learning; Hewson (1982) stated that these assertions which are considered valid for the study are as follows;

a. Each of us individually constructs our own meaning of experiences.

b. Therefore understanding is individual as individual's constructions are different.

c. Much of the construction we undertake as we generate our own understanding involves linking new ideas and experiences with what we already know or believes.

However, Davis (2001) suggested that where the conception a learner already has is faulty i.e. does not correspond with scientific views, such conception is said to be erroneous and thus labeled as alternative conception or misconception. In line with this, Davis also stressed that a number of studies have shown that the learners personally constructed knowledge (conception) do differ from currently accepted scientific views. This personally constructed wrong idea that has been previously labeled by science education researchers as alternative conceptions has been a source of concern. This is because of the negative effect the misconceptions have on the learners understanding of scientific concepts. Thus, the problem of how to shift these wrong ideas to scientifically accepted views continued to be a source of worry to science educators. However, Taber (2011) suggested the use of conceptual change instructional strategy in tackling the issues on conception.

The initial researchers like Davis (2001), Taber (2011) who used conceptual change instructional strategy, took the inspiration from the work of psychologist like Thomas Kuhn and Piaget who based their theory of construct of dis-equilibrium and paradigm shift in the area of philosophy of science. Thomas Kuhn and Piaget believed that to effect a change in the misconceived ideas of the learner and for effective learning to take place, prior knowledge of the learner must be considered. As meaningful learning can only take place when a general subsuming concepts is already available in the learners' cognitive structure. Posner et al, (1982) revealed that for learning to take place, there must be a change in the learners' conception as well as addition of new knowledge to what is already learnt. The present study will search the cognitive structure of the learner with the aim of identifying the misconceived notions they have which are unscientific. The study will use an adopted model of the conceptual change instructional strategy of Posner et al (1982), to remediate the misconceived notions of the students about acid and base concepts in chemistry.

#### 2.3.1.2 Misconceptions

Misconceptions can be referred to as a preconceived ideas or a conceptual misunderstanding. These are cases in which something a person knows and believes does not match what is known to be logically correct. A lot of people who hold misconceptions do not even know that their ideas are scientifically incorrect. People interpret the world that is received by their sensorial experiences in a way that makes sense to them. Canpolat(2006), Pabuçcu and Geban (2006) observed that these interpretations may vary from person to person and usually they are simplistic and are not in agreement with the accepted theories of science. They are called misconceptions. When they are told they are wrong, they often have a hard time giving up their misconceptions, especially if they have had a misconception for a long time. However, learning is retarded. The learner also becomes resistant to change thus, creating obstacles to further learning.

Taber(2011) stressed that misconceptions play a larger role in learning chemistry than simply producing inadequate explanations to questions. Students either consciously or subconsciously construct their concepts as explanations for the behavior, properties or theories they experience. However, learners believe most of these explanations are correct because these explanations make sense in terms of their understanding of the behavior of the world around them. Demircioglu, (2009) suggested that a cognitive conflict arises when learners are faced with new information that differs from their established conception, the students being put in a position to either change their rather naive view into a scientifically accepted one (for this to happen, a conceptual change must be developed first) or, otherwise, to reject or ignore this new information simply because it seems wrong.  Possessing misconceptions can have serious impacts on an individual's learning. Misconceptions are a serious problem because they are resistant to change, they are an obstacle for learning by understanding and they can even be dangerous. It is so dangerous because it may suggest to pupils that they can play with kites during a storm and be safe.

kwen (2005) also added that studies in students alternative conceptions in science have a long history, being traceable back to Piagets early work on children's view of natural phenomena. Piaget (1970) reported that there is now a substantial body of literature documenting the various types of misconceptions or alternative conception held by students in various conceptual areas. Misconception can be described as ideas that provide an incorrect understanding of such ideas, objects or events that are not in agreement with our current understanding of natural science. Misconception can occur in students understanding of scientific methods as well as in their organization of scientific knowledge. The National Council (NRC) (1997) presents five types of misconceptions that can interfere with learning of science:

1. preconceived notions
2. nonscientific beliefs
3. conceptual misunderstanding
4. vernacular misconception
5. factual misconception

Some common misconceptions in science according to New York Science Teacher (NYST, 2010) are:

1. Objects float in water because they are lighter than water
2. The bubbles in boiling water contain “air” oxygen or “nothing” rather than water vapor.
3. The moon does not rotate on its axis as it revolves around earth.
4. The phases of the moon are caused by shadows cast on its surface by other objects in the solar system.
5. Seasons are caused by the earth distance from the sun.
6. Evolution is only a theory because it has not been proved.
7. Dinosaurs, human and cavemen lived at the same time.
8. Human are responsible for the dinosaurs.
9. The terms energy and force have the same meaning.
10. Batteries have electricity inside them.

According to Okebukola (2002) unscientific preconception of natural phenomena indicates that new concepts cannot be learned, as an alternative model that explains a phenomenon already exists in the mind of the learner. These unscientific preconceptions are as follows:

a. Preconceived notions – these are popular conceptions rooted in everyday experiences. For example, many people believe that water flowing underground must flow in streams because the water they see on earth’s surface flows in streams.

b. Nonscientific beliefs- these include views learned by students from sources other than scientific education, such as religious or mythical teachings. For example, "the debate" between evolutionary theorists and creation of scientist is one of a current controversy in education.

c. Conceptual Misunderstanding - these arise when students are taught scientific information in a way that does not challenge them to confront paradoxes and conflicts resulting from their own preconceived notions and nonscientific beliefs. To deal with their confusion, students construct faulty models that usually are so weak that the students themselves are insecure about the concepts.

d. Vernacular Misconceptions- these arise from the use of words that mean one thing in everyday life and another in scientific context. e.g. words like "power", "wave" and "field" can have very different meaning used in science class verses everyday life.

e. Factual Misconceptions - these are falsities often learned at an early age that remain unchallenged into adulthood. For example, the idea that "lightning never strikes twice in the same place" is clearly nonsense, but the notion may be buried somewhere in learner's believe system.

Lawal (2009), opined that vernacular and factual misconceptions can easily be corrected even by students themselves. Preconceived notion, non-scientific beliefs and conceptual misunderstanding requires extra effort from the teacher to get it corrected. From the above listed and explained types of misconception, the researcher intends to test the conceptual misunderstanding.

### 2.3.1 Sources of Students' Misconceptions

Students develop their scientific conceptions from many sources; those sources have always created inconsistent frameworks or incorrect representation of the scientific concepts. Chui, (2005)stressed that the sources resulted from personal experiences for example, observation, gender, peer interaction, media, language, symbolic representation, textbooks, laboratory works, environmental, social, religion among others. Adedoji (2008) advocated that sometimes teachers serve as another major source of alternative misconceptions when using inappropriate method of teaching. Lee, (2004) also revealed that students at different ages held similar misconceptions that influence their understanding of more complex concepts. Demirici, (2001) confirmed that there is a growing number of researchers devoting their efforts to science learning, science educators have developed instruction interventions for conceptual change in learning science, but they offer only limited representative information about the difficulties or misconceptions held by learners when learning chemistry.

Although, much research has focused on investigating, students' misconception and developing teaching strategies for conceptual change, few researchers have focused on exploring the causes behind the misconceptions. For instance, Chui (2005) argued that language in chemistry can cause or increase misconception because the meanings of the same word in chemistry are different from the language used in daily life. Also, Oversby (2000) argued that models used in textbooks only provide explanations of phenomena, and they have their strengths and limitations in relation to misconception. Accordingly, this study intends to use conceptual change instructional strategy to remediate misconceptions in acid and base concept.

### 2.3.2 Misconception in Chemistry Concepts

Many students display a lot of misconception of chemical concept. Many concepts in chemistry are important for learning and understanding how the world functions in daily life. However, students either before or after school instruction cannot develop an appropriate structure of chemistry concept. For instance, students' conception of matter as a collection of moving particles in rudimentary and the instruction in this area is not as effective as might be expected. Modic (2011) found out that majority of students tended to consider matter as having continuous particles characteristics. Also Treagust, (2010) found out that high school students considered that air is composed mostly of oxygen and heavier objects fall faster than lighter ones.

For the concept of chemical equilibrium, Pekmez, (2010) found out that students had difficulty in understanding the dynamic nature of chemical equilibrium. A study of Cliff (2009) revealed that even college students equivalent to university students did not understand how adding a solid solution influenced the equilibrium state. Oxidation and reduction topics were also shown to be difficult topic for student to conceptualize. Garnett, (2016) discovered that students believed that oxygen that made the iron rust was from water and that the rusted iron had the same weight as the original iron. As for the characteristics of matter Yizierski and Birk (2006) revealed that students believed that matter (e.g magnesium) decreased in weight after burning of candle to be a physical change and the process of dissolving sugar to be chemical change.

Consequently, Harizal, (2012) discovered that 10th grade students (equivalent to senior secondary school 1) believed that acids tastes bitter and hot while Origil and Sutherland, (2008) also found that $4^{th}$ and $5^{th}$ grade (equivalent to primary school pupil) did not have well developed concepts about how to differentiate acids and bases. Metin, (2011) revealed that students had difficulty in identifying whether a substance was an acid or base but their teachers had difficulty as well. In the aspect of misconception of the structure of atoms, Sarikaya, (2007) narrated that students perceived that only one model of the atom is correct.

The present study therefore aimed at identifying the misconceptions held by SSI chemistry on acid-base concepts.

### 2.3.3 Misconceptions in Acids and Bases Concepts

Chemical education researchers like Ozmen Demircioglu, Naseriazer and Burhan, (2012) have recognized that students often have difficulty and misconceptions in learning chemistry concepts, and have proposed several suggestions as to the reasons for these difficulties and misconceptions such as, frequent overloading of student working memory, misinterpretation of concepts among others. Some of the misconceptions identified by Ozmen et al., (2012) on acids and bases concepts include;

1. An acid is something that eats materials away or which can burn you.
2. Testing for acids can only be done by trying to eat something away.
3. The difference between a strong acid and weak acid is that strong acids eat materials away faster than weak acids.
4. Neutralization is the breakdown of acid and something changing from an acid.
5. All acids and bases are harmful and poisonous.
6. As the pH increases acid becomes harmless and bases are not harmful.
7. Strong acid is always a concentrated acid.
8. Acids are more dangerous than base.
9. Soil cannot be acidic because things grow plants on it.
10. Fruits are bases.
11. $H_2O$ are solvent and not act as acid and base.
12. Acid and base show opposite properties of each other.
13. All acids taste bitter.
14. All materials that have a sharp and strong smell are acid.
15. All acid and base conduct electricity in the same manner.
16. Materials that contain $H^+$ are acidic and those that contain $OH^-$ are basic

This study therefore intends to investigate the effects of conceptual change instructional strategy in remediating misconception on acids and bases concepts among senior secondary students.

## 2.4 Conceptual Change Instructional Strategy and Learning of Science

There are many ways to get humans to learn, but a deep understanding of concepts is not always achieved when teaching students. Students often memorize through rote memorization, but do not conceptually understand because humans interpret their world based on the concepts that make up their own understanding of the world also known as their "conceptual framework". This unique lens is a byproduct of the sum of all of an individual's experiences.

Conceptual change instructional strategy denotes learning pathways from students' pre-instructional conceptions to the science concepts to be learned. Mason and Boscolo, (2000) defined conceptual change instructional strategy as a teaching strategy that requires students to reorganize the conceptual framework in order to learn something. The researchers opined that humans construct meaning from experiences in their everyday lives and many times those concepts are not in harmony with scientific phenomena. This requires for the reorganization of concepts by students in order for them to completely learn and understand a concept. Mason (2001) believed that conceptual change has become the term denoting learning science from constructivist perspectives and has been employed in studies on learning and instruction in a number of domains other than science. Davis (2001) stressed that conceptual change model gained grounds in effecting a shift in the different types of misconceptions that are prevalent in science educational system today.

Sungur, Geban and Tekkaya (2006) showed that the instruction based on conceptual change instructional strategy facilitated students' understandings of science subjects better. Research on the concept of conceptual change has developed a unique vocabulary because conceptual change can happen at a number of levels and different authors use alternative terms to describe similar learning. Harrison and Treagust (2000) stated that there are two types of conceptual change, variously called weak knowledge restructuring, assimilation or conceptual capture and strong/radical knowledge restructuring, accommodation or conceptual exchange. While some authors separate knowledge accretion from conceptual change others include it as a third level. Consequently, the term conceptual change has been given various meanings in various literatures. Duit and Treagust, (2003) revealed that the term change often has been misunderstood as being an exchange of pre-instructional conceptions for the science concepts. In this review, we do not use conceptual change in this way. Rather, we use the term conceptual change for learning in such domains where the pre-instructional conceptual structures of the learners have to be fundamentally restructured in order to allow understanding of the intended knowledge, that is, the acquisition of science concepts.

Teichert and Stacy (2002) urged that recent research on science education showed that traditional instruction is not sufficient for students to understand concepts clearly, and to integrate students' ideas into coherent conceptual framework. Akkuş, Demircioğlu, Ayas and Demircioğlu, (2003) opined that new teaching and learning strategies which are based on constructivist view of learning were developed to overcome students' alternative conceptions in science education. In this view, the notions that knowledge is constructed by the individual through his interactions with his environment and the process of learning is the interaction between new knowledge and existing knowledge accepted as important ingredients of learning. Geban and Ceylen (2010) advocated that one of the effective instructional methods that overcome students' alternative conceptions and improve students understanding in science education is the instruction based on conceptual change approach. The conceptual change instructional strategy deals with the specific conditions whereby existing structures are modified by new information. Also, conceptual change instructional strategy is based on the constructivist notion claiming that learning is a process of personal construction of knowledge. One of the conceptual change models was proposed by Posner et al. (1982).

Posner et al., (1982) proposed a model of conceptual change instructional strategy that takes inspiration from Thomas Kuhn’s description of scientific revolution. Kuhn,(1970) noted that scientific revolution follows a particular pattern prevailing scientific paradigm had to be in a “state of crisis” by failing to produce some solutions to problems that the scientific community felt it should address. An alternative paradigm which promised to solve those problems which had influential adherents, had to be available. Posner et al, (1982) adapted Kuhn’s ideas and formulated the following set of conditions for conceptual change.

a. The student must be dissatisfied with currently held conceptions. The naïve conception must appear inadequate to solve an existing problem.

b. The new conception or alternative conceptions must be understandable (it has to be intelligible).

c. The student must believe that this alternative conception is plausible or useful in solving the problem at hand.

d. The student must see how using this alternative conception could help solve problems or answer questions: this means the alternative concept should be fruitful and capable of solving future problems.

Posner et al. (1982) defined the ‘status’ of an idea held by a student as determined by the conditions above. This means that if an alternative idea is intelligible, plausible and seems to offer promise of being useful, then it has a high status. However, the model described learning as a process in which a person changes his or her conception by capturing new concretions or exchanging existing conception for new conceptions. The more recent revision (e.g. Strike and Posner, 1992) argued that instructions based on the model should take into account students motivation and the role that prior conception plays in their conceptual ecology.

In this study an adapted model of Posner et al (1982) will be used to remediate misconceptions held by SSII students of chemistry about the concept of acids and bases.

### 2.4.1 Teaching Models for Conceptual Change

The goal of teaching for conceptual change is for students to adopt more fruitful conception, while discarding the misconception they bring to the learning environment. However, conceptual change instructional strategy models are of different types such as;

Osborne and Cosgrove (1985), proposed the Generative Learning Model of Teaching for conceptual change. In the Generative Learning Model of Teaching (GLMT) the learner is an active participant in learning process. The GLMT has four instructional phases aimed at enabling the learner to construct meaning. The phases are as follows:

a. Preliminary phase: during this phase the teacher ascertain students ideas, expectations and explanation prior to instruction

b. Focus phase: the teacher provides context through motivation and provide experience related to the concept.

c. Challenge phase: the teacher facilitates the exchange of views and challenge students to compare ideas including the evidence for the scientific perspective.

d. Application phase: the teacher provides opportunities for the students to use the new ideas/scientific conception in familiar setting.

Posner et al., (1982), proposed a model of conceptual change, which had four conditions, taking into cognizance the four conditions such as:

1. Learner must become dissatisfied with their existing conceptions i.e. they must have experiences, which lead them to lose confidence in the ability of their current conception to solve problems.
2. The new conceptions must be intelligible i.e. the student must be able to understand sufficiently how experience can be structured by the new concept.
3. The new conceptions must appear plausible i.e. any new concept adopted must at least appear to have the ability to solve the problems generated by its predecessors.
4. The new conceptions must be fruitful i.e. it should have the capacity to open up new areas of inquiry.

The major property of the model is that it is for the creation of awareness of problems, management of cognitive dissonance and cooperative work to ensure meaningful learning.

Posner et al., (1982) proposed the following steps;

a. Students' preconceptions.
b. Increasing inconsistencies of preconceptions.
c. Dissatisfaction with preconceptions.
d. Turning to new scientific conceptions which must be:

   Intelligible

   Plausible and

   Fruitful to allow for:
e. A shift from preconception to new scientific conception which will lead to:
f. Accommodation of new scientific validated conception.

The model described learning as a process in which a person changes his or her conception by capturing new conception or exchanging existing conception for new conception.

A flowchart illustrating Posner et al model is shown in Fig 2.1

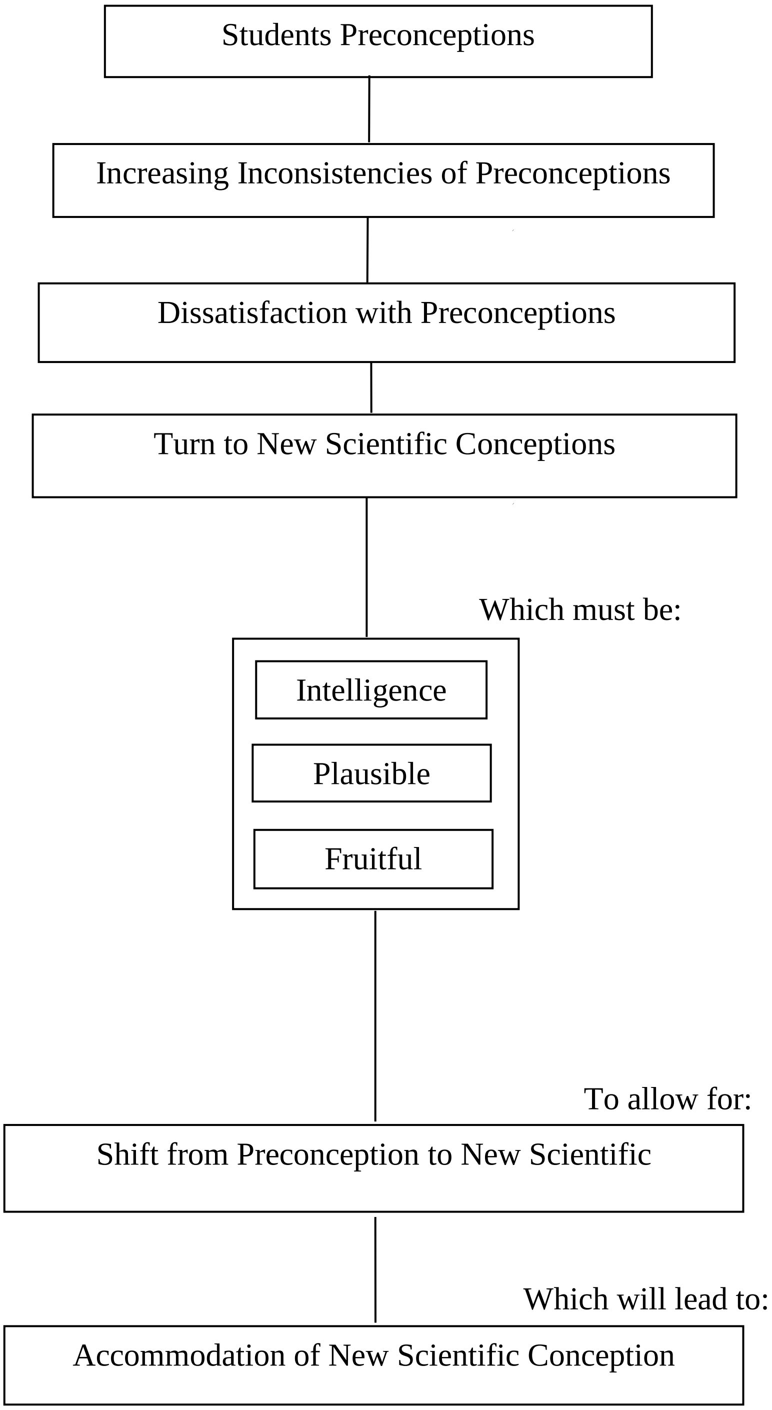



**Figure 2.1: Flowchart of Conceptual Change Instructional Strategy**
Source: Posner et al (1982)

Driver (1980) proposed the following model of teaching for conceptual change using constructivist approach. The model has the following stages;

a. Orientation stage: Here, the student's attention and interest in the topic is aroused. At this time the class or group spends time discussing their ideas.

b. Elicitation stage: This is usually done in groups. Each group is expected to present its ideas and conception about the concept under investigation on a poster, a flip card, a sideboard or by other means. At this stage the similarities and differences in student's preconceptions are identified and clarified. The writing (poster) is allowed to remain on display as long as work on the unit lasts.

c. Restructuring stage: At this stage, students are given the opportunity to use various strategies to try out their conception and the revised conception. The strategies to be employed may include practical, extensive reading viewing films, generating proposals and counter-proposals and creating scenarios.

d. Classification and Exchange: At this stage, after the learners have been given the opportunity to test their conceptions against the revised conception, they are then given another opportunity to review the extent to which their thinking has been changed.

e. Evaluation: Here, the instructional strategy is evaluated to find out the effectiveness of the strategy on the performance of the students

Roth's (1985) model of conceptual strategy has the following features;

a. Eliciting: The teacher first identifies common misconceptions focusing on explanation.

b. Focusing: The students' misconceptions are activated by presenting students with situations designed to elicit a prediction based on their probing students' responses.

c. Probing: Introducing common misconceptions followed by evidence that they are accurate or misleading challenges the students’ misconceptions.
d. Balancing: After the discussion of students’ responses and scientifically accepted ideas, the instructor or teacher presents the correct scientific explanation.

The Powerful Ideas in Physical Sciences (PIPS) model has the following phases described by Lilly and Sirochman (2000) as the PIPS five Instructional Phases;

a. Phase 1: Eliciting and elaborating the students’ ideas.
b. Phase 2: Testing and comparing the ideas with nature.
c. Phase 3: Resolving the discrepancies between ideas.
d. Phase 4: Applying the ideas.
e. Phase 5: Reviewing and summarizing of ideas.

Neidderer (1987) on the other hand, proposed a model for conceptual change. The strategy was reported as consisting of six steps:

a. Preparation: The teaching process which precedes the intervention and which may contain tools and concepts that may be drawn on.
b. Initiation: An open - ended problem is posed.
c. Performance: This is all about formulating questions or hypotheses, planning and performing experiments, making observations, theoretical discussions and formulation of findings
d. Discussion of findings: This is done in a class forum.
e. Comparison with science: Class findings are compared with similar historical theories or modern ideas. Differences are stated and possible reasons for those differences are discussed.

f. Reflection: Students are encouraged to look back on the process of performance and to consider particular questions or difficulties, which have arisen.

The researcher intends to use Posner et.al (1982) instructional strategy of teaching for conceptual change. This is because in the model, students are made aware of the misconceptions which they hold. The students or learners are made to be dissatisfied with the misconceptions, and with the aid of the teacher as a facilitator students are helped to encounter the scientific explanation of the event or phenomenon in question. This procedure eventually leads to conceptual change. Also several science education researchers have showed that conceptual change approach provided a better acquisition of scientific conceptions and removing students' alternative conception

**Lecture Method of Teaching**

The aim of teaching is to transfer knowledge. For effective teaching and learning to take place, teachers need to use method and technique in teaching. Methodology is very vital in any teaching-learning situation. Ameh and Dantani, (2012) emphasized that the method adopted by the teacher may promote or hinder learning. It may sharpen mental activities which are the bases of social power or discourage initiatives and curiosity thus making self-reliance and survival difficult.

Lecture method originated from Plato's method of teaching secondary school students as far back as 425BC-347BC. Obeka (2009), described conventional method as a traditional talk-chalk method of teaching in which the teacher does most of the talk, while the students listen and take down note. Njoku (2004) opined that the lecture method is also known to cause lack of interest and poor performance in science. Akpan (2004) specifically stated that lecture method is the method dominating science teaching in Nigerian Secondary Schools.

Ameh and Dantani (2012) opined that teachers use lecture method in order to overcome the bulky chemistry syllabus before the SSCE and this affects students' performance. Okebukola (2002) have called for a change from lecture method for teaching chemistry. This is because of its disadvantages in the learning of science in science classrooms.

The following are some advantages of lecture as a teaching strategy:

1. Lecture method leads to easy coverage of the school syllabus, which unfortunately is the main concern of science teachers and the society generally. The method leads to coverage of large amount of materials to a large class size in a single period.
2. The lecture is convenient method for instructing large groups. If necessary, we can use a public address system to ensure that all students can hear. The lecture is sometimes the only efficient method to use if student-to-faculty ratio is high.
3. The lecture is particularly suitable for introducing a subject. To ensure that all students have the necessary background to learn a subject, we can present basic information in a lecture. By using the lecture in this manner, we can offer students with varied backgrounds a common understanding. A brief introductory lecture can give direction and purpose to a demonstration or prepare students for a discussion.

Although the lecture method can be effective and efficient teaching method, it has a number of disadvantages.

1. The lecture does not lead to maximum achievement in certain types of learning. Because it those not allow for development of skills, concepts and principles that require practices.

2. Too often, the lecture makes no provision for participation by students As a result, many students willingly allow the instructor to do all the work. Learning is an active process, but the lecture method tends to foster passiveness and dependence on the instructor.

3. Finally, many instructors find it difficult to hold the attention of their students when they lecture for an entire class period.

Therefore there is the need to find out the effect of traditional method of teaching in remediating misconceptions students harbor about acids and bases concepts in chemistry, the use of traditional method in learning is thus one of the major focuses of this study.

## 2.5 Remediation Strategies

The fact that misconceptions are difficult to remove calls for more concreted efforts to elimination. After a series of identification of misconceptions, the 4$^{th}$ international seminar in 1997 devoted some attention to the remediation of misconceptions through educational strategies. This is because teaching and learning could be viewed as complementary as action and reaction or cause and effect. However, it is known that good teaching can take place without a corresponding learning occurring. This arises mainly from the fact that learning is an individual's activity which must be contemplated upon for it to take place. Besides, a learner must be well composed and concentrate on the teaching episode for meaningful learning to occur. Unfortunately, every learner comes to class with some preconceptions or ignorance of a particular subject matter. With an open mind to learn, ignorance is easily transformed to knowledge through understanding of the revelation from teaching. However, a problem arises in replacing a preconception that is wrong with a correct conception. This is particularly so if the wrong conception or misconception arises from common sense application or it has root in public usage or supposed authority. One may also have become used to the usage such that even with superior knowledge, there is the tendency to slip back to the wrong but rather comfortable familiarity.

Knowledge is not passively received, but is actively build up by the cognizing subject for a learner to be able to build up knowledge, demands that the leaner should understand and be knowledgeable.

Remediation strategies of learning have encouraged researchers to look for the connection leaners make when information is received. According to Gunstone (1990) research is beginning to uncover such connections between incoming scientific information and the nonscientific content of the mind. The leaner uses these non-scientific content as a basis upon which incoming ideas will react to generate new knowledge. It is this view that the learners is not passive but actively engage in remedial study, that constitutes the core or central focuses on the remediation strategy of science learning teaching. Remediation strategy therefore, is not a transmission of knowledge rather, it involves the organization of the situation in the classroom and designing of task, materials and resources from which students construct their own scientifically valid ideas or knowledge. This calls for a different model or strategy to science teaching and learning. Otuka (1991) described remediation strategy as an approach in which the teacher becomes the enable or facilitator in the classroom where he interact with learners raise thought provoking, questions, build misappropriate challenges and experience and offer new way of thinking scientifically.

However, following the result of science researchers like, Geban, (2006), Lawal, (2009) and Lakpini, (2006) among others, the following generalization could be derived concerning learners ideas:

a. Most learners have naïve theories or ideas concerning the natural world, even inclosing the best student in the educations sustain.
b. Each students explanation of the things around them comes from their own experience can opposed to what is taught.
c. Altering misconceptions occurs through personal challenge to the concept, thereby creating situation where the erroneous conceptions does not explain.
d. Learning is a society activity, even when an individual construct explanation for him/her self it must be communicated and validated.

These findings above gave more support to the remedial strategy model. This strategy demands newer approaches and suggest such approach as to:

a. Allow students thinking to derive a lesson or entire unit
b. Shift activities and content plan to the student responses, interest and ideas
c. Encourage students initiated of ideas, display of leadership, autonomy in planning and doing.
d. Allow adequate wait-time for students to interact frequently with other students and other outside the particular class.
e. Use open-ended and thought provoking question, encourage the same from students.
f. Offer alternative suggestion and encourage them to get suggestion from other students and use these as challenges to misconception.

Research have been conducted on remediation strategies among other are, Hand and Treagust (2009) identified misconception about acids and base in students as acid is something which eats materials away and can burn, testing of an acid can only be done by tying to eat something away, to neutralize is to break down an acid or to acid or to change from an acid, a base is something which makes up an acid and a strong acid can eat materials away faster than a weak acid. However the study used conceptual change instructional strategy accompanied by simulation and cartoon as the remediation package. Hassan (2017) identified misconception and academic achievement in practical chemistry some of the misconceptions among other are: strong acid required little of water for dilution while week acid require large amount of water for dilution. Indicators are object used for identifying a particular substance, methyl orange is suitable for all types of reaction and PH of any given salt solution is neutral. Lastly mixture of sugar and water can be separated by filtration and mixture of kerosene and water can be separated by distillation and titration. The misconceptions sorted from the study were remedied using the Powerful Ideas on Physical Science (PIPS). Lawal, (2009) diagnosed secondary school students misconception in genetics using a misconception test among the alternative preconception sorted out were animals cell is like a cycle while the plant cell is like a square. Energy help in the life or growing of the body solar energy is the energy needed by animal activities. Chlorophyll is responsible for reproduction. Cell is a muscular organ which is found in the body it is a tiny particle used for the abortion of minerals in the body. The difference between plant and animals cell is wall. However Lawal (2009) adopted and identified a strategy called conceptual change instructional strategies as the remediation package.

The present study used conceptual change instructional strategy as a remedial package on the identified misconceptions on senior secondary school students.

## 2.6 Academic Performance in Chemistry at SSCE

The role of chemistry in our daily and national life as well as in the industry is undaunted. Many of our day-to-day activities revolve around chemistry. Oloyede, (2010) Opara and Waswa, (2013) revealed that chemistry is everywhere; chemistry is life; chemistry is the oracle and crown prince of modern science. Jegede, (2010)and Oloyede, (2010) stressed that despite the key role of chemistry as the central science that forms the basic foundation to many disciplines and in improving the quality of life, the performance of Nigeria secondary students in the subject has for many years remained a matter of a serious concern. Udoh,(2008) affirmed that efforts made through research to discover the causes of the persistent failure revealed among others, that secondary school chemistry teachers mainly adopt the lecture method in the teaching and learning of chemistry. Lovat,(2003) posit that "teaching is not an incidental craft to follow naturally from mastery of subject content, but a highly complex blend of theoretical understanding and practical skill". According to Jodi,(2010) emphasis on traditional approaches and coverage of content mapped out in the school syllabus and scheme of work for the three recently introduced 9-3-4 system the senior secondary position has not changed) in Nigeria have resulted to students learning chemistry without conceptual understanding. Hamid and Azita (2009) identified some of the reasons for this failure which includes laboratory inadequacy, teacher's attitude, examination malpractice, non-professionalism and environment. Lawrence and Abraham (2011) opined that instructional strategy in schools is aimed at giving the students the opportunity to gain meaningful learning, acquire appropriate skills and attitude that enables them live and contribute to the development of the society. In this study, therefore there is a need to investigate the performance of students in acid and base concept chemistry.

### 2.6.1 Gender and Academic Performance in Chemistry

In this study, gender and academic performance in science and chemistry in particular, appears relevant as one of the research questions focused on gender and academic performance. For this reason, gender and academic performance in science (chemistry) is reviewed briefly. The role of gender in science achievement test has resulted to studies over time by scholars among others are; Bunkure (2007) advocated that many studies carried out on gender effect on academic performance have led to number of conciliating conclusions, some find gender as a relevant fashion in academic performance, others found that there is no difference existing between sexes in this area. Usman (2007) found that boys performed well in vigorous work while girls show settle seated for less vigorous work.

Avwiri and Nbina (2014) and Muhammad,(2014) in separate studies, reported that gender has no effect on student achievement in science. Also Omwirhiren, (2013) and Daluba, (2013) noted that the male perform significantly better than their female counterparts in evaluating science concepts. The consensus among science educators is that some instructional strategies are gender bias while some are gender friendly however, the degree of gender related differences in learning vary from one method of instruction to the other as well as the concept being learnt. In this study therefore there is a need to investigate the issue of gender differences on academic performance in acid base concept using conceptual change instructional strategy.

## 2.7 Overview of Similar Studies

This section provides insight into relevant or related studies on remediating misconceptions in science and hence identifies research gaps. A study was carried out by Rollnick and Rutherford (2011) on “The use of Conceptual Change Model and Mixed Language Strategy (MLS) for Remediating Misconceptions on Air and Air Pressure”. The main objective was to use the strategy of Conceptual Change Instruction mixed with indigenous language for primary teachers in Swaziland. The study design was experimental using comparative method between CCIS and traditional method. The study involved 200 trainees primary school teachers which were successfully used as intervention to remediate the misconceptions on air and air pressure among the pupils. The major research finding after comparison with the traditional Strategy of instruction proved CCIS most effective. The similarity of this research with present study is comparing the effectiveness of the use of Conceptual Change Instructional Strategy with traditional strategy as a remediation package. The differences are in the concepts taught and the use of Mixed Language Strategy.

Pabuccu and Geban (2006) worked on Remediation of Misconceptions Concerning Chemical Bonding through Conceptual Change text on 41 ninth grade students (equivalent to junior secondary school III) enrolled in a chemistry course in a private high school in Putyk, Turkey. The purpose of the study was to explore the effects of conceptual change texts oriented instruction on students' understanding of chemical bonding concepts. Quasi experimental design was used for the study. The age of the students was 14-15 years. Students were selected from two intact classes whose teacher volunteered to participate in this study. One of two instructional methods was randomly assigned to each class. The data were obtained from 21 students in the experimental group using conceptual change texts oriented instruction accompanied with analogies and 20 students participating in the control group receiving traditional instruction. Chemical Bonding Concepts Test (CBCT) was developed by the researchers to determine students' understanding of chemical bonding concepts. Analogies were used in the conceptual change texts to deal with students' misconceptions more effectively. The results revealed that conceptual change texts oriented instruction produced a positive effect on students understanding of scientific conceptions related to chemical bonding and elimination of misconceptions. The mean scores of both groups showed that students in the experimental group performed better with respect to chemical bonding concepts. The reviewed work is similar to the present study in that both examined the effect of conceptual change instructional strategy in remedying misconceptions in chemistry concepts but the difference is that former was on chemical bonding while the latter is on acids and bases concept.

A study by Kaya (2011) investigated the effects of Conceptual Change Based Instruction Accompanied by Demonstrations (CCBIAD) and gender on 11th grade students'(equivalent to senior secondary school II) understanding and achievement in rate of reaction concepts and their attitudes toward chemistry as a school subject compared to Traditionally Designed Chemistry Instruction (TDCI). Sixty nine 11th grade students from two classes in a public high school in Ankara, Turkey Participated in this study in the Fall Semester of 2008-2009. These classes were randomly assigned as control and experimental groups. In the control group TDCI was used, while in the experimental group CCBIAD was used as instructional methods. Rate of Reaction Concept Test (RRCT), Rate of Reaction Achievement Test (RRAT), and Attitude Scale towards Chemistry (ASC) were administered to both groups as pre-tests and post-tests to assess students understanding of rate of reaction concepts, achievement in these concepts, and attitudes towards chemistry, respectively. The hypotheses were tested by using Analysis of Covariance (ANCOVA) and Two- Way Analysis of Variance (ANOVA). The results show that CCBIAD used was significantly better acquisition of scientific conceptions related to rate of reaction than TDCI and helped in remediating misconceptions. In addition, there was a significant effect of CCBIAD on students' attitudes toward chemistry. There was no significant effect of gender on both students' understanding of rate of reaction concepts and their attitudes toward chemistry. The revived work is similar to the present study in that both examined the effect of conceptual change instructional strategy in remedying misconceptions in chemistry concepts but the difference is that former was on rate of reaction while the latter is on acids and bases concepts.

In trying to remediate misconceptions, Aydin (2012) conducted a research on, Remediation of Misconceptions about Geometric Optics using Conceptual Change Texts. The researcher utilized the conceptual change text among 90 sophomore students taught by same lecturer in two separate sections in the Department of Science Education of Agriculture, faculty of Education at Ataturk University Turkey. The research question do prospective science teachers have any misconceptions about the subjects of refraction and reflection in the optics course was asked and a null hypothesis there is no significant difference in the prospective science teachers having misconceptions about the subjects of refraction and reflection in the optics course was. In other to identify misconception, a three-stage pre-test, a classical exam and a ten-student interview was administered on the sub-topic of reflection, refraction and diffusion of light. The study showed that the conceptual change instructional texts are more effective than traditional method of instruction. The limitation of Aydin's study is that the study area is too small for generalization.

Taslidere, (2013) investigated the Effect of Conceptual Change Oriented Instruction Accompanied by Concept Cartoon Worksheet with Simulation on Students' Conceptual Understanding. The study was twofold: first investigated the effect of conceptual change oriented instruction accompanied by concept cartoon worksheet with simulation on students' conceptual understanding and second to remedy their misconceptions of direct current electric circuits. Participants were 139 pre-service science teachers from four intact classes in Bursa, Turkey. A quasi-experimental design was used in the study. The experimental group studied the concept with the application of concept cartoon worksheet and simulation, and the control group studied it with traditional instruction. Students' conceptual understanding and misconceptions were measured by a tree-tired misconception test. It was administered as pre-test and posttest. There was no significant difference between the means of pre-test scores of experimental and control groups. The main effect of treatment on post-test scores was examined via ANCOVA with pre-test scores used as covariate. The frequency of each misconception was calculated for both groups, from pretest to posttests regarding all tiers of items. The analysis yielded a significant treatment effect on students' posttest performances. The findings indicated that the conceptual change oriented instruction accompanied by concept cartoon worksheet and simulation is effective for conceptual understanding and decreasing most of students' misconceptions in direct current electric circuits. The work is related to the present study in such a way that both of them are on ways to remedy misconception through conceptual change instructional strategy. However, it differs in the type of concepts taught and teachers were used instead of students.

Sendur and Toprak (2013) carried out a study on the Role of Conceptual Text to Improve Students Understanding of Alkenes. The purpose of the study was to investigate the influence of conceptual text on students' understanding and misconceptions and learning difficulties regarding alkenes in Johor, Malaysia. The participants of the study consisted of 63 second year student from primary science education department. From the sample 33 were placed in experimental group and 30 in control group. A quasi experimental designed was used and the statistical instrument used was Alkenes Concept Test (ACT).The researcher revealed that conceptual change texts are effective in facilitating students conceptual understanding of alkenes. The research work is related to the present study in terms of instructional strategy used (conceptual change) and design but the difference lays in the concepts and instrument used.

Karpudewan, Roth and Chandrakesan (2015), worked on Remediating Misconception on Climate Change among Secondary School Students in Kwlantan, Malaysia. The sample for this study consisted of 73 Form Four science stream students which were between 16 and 17 years of age. A quasi-experimental design involving experimental and control groups with pre-test as covariate. The three-tiered 13-item Atmosphere-Related Environmental Problem Diagnostic Test (AREPDiT) adapted from Arslan, Cigdemoglu and Moseley (2012) was used in this study to measure understanding, obtain information about possible reasons for answers, and gather information about students' level of confidence. In the study, two classes from two different schools were randomly assigned to experimental (N = 35) and control condition (N = 38). Following the intervention, an ANCOVA with pre-test as the covariate showed statistically significant differences. The outcome of ANCOVA analysis and interview responses indicate that the experimental students exhibited significantly improved understandings and fewer misconceptions about global warming, greenhouse effects, acid rain, and ozone layer depletion. The climate change activities as used in this study provided a context for the students to learn while actively engaging in tasks with others rather than attending a teacher-centered course.

Lawal (2009), worked on Effectiveness of Conceptual Change Instructional Strategy in Remediating Misconceptions in Genetics Concepts Among Senior Secondary School Students in Kano State Nigeria. The researcher identified some common misconceptions that Senior Secondary Two (SSII) students of Biology harbor on the concept of genetics and even went further to ascertain if conceptual change instructional strategy would remedy the identified misconceptions. The study sample of 218 SSII students were drawn from two girls and two boys' secondary schools randomly selected in Kano metropolis. The study adopted the pretest-posttest experimental and control design. Three instruments were used for the study; Misconception Test in Genetics Concepts (MTGC), Genetics Concept Achievement Test (GCAT) and Instructional Attitude Change Questionnaire (IACQ). The finding of the study among others is that misconceptions can be remedied by the use of conceptual change instructional strategy. The reviewed work is closely related to the present study in the sense that both studies focused on “the effect of conceptual change instructional strategy in remediating misconceptions” however, the difference between the two studies is that the former is about genetics concept in Biology while the latter is about acids and bases concept in chemistry.

Elsewhere, Ikenne (2014) conducted a research on “Remedying Students Misconceptions in Learning Of Chemical Bonding and Spontaneously Through Interaction, Discussion Learning Models (IDLM)” and identified the various misconceptions college of education students hold about bond energy and spontaneity and apply conceptual change instructional strategy (intervention discussion learning model) to remedy the misconception and improve achievement. The study used pretest posttest quasi experimental research design. The population of the study included all final year students of all the three colleges of education in Kano state, but the scope was delimited to eighty (80) final year NCE students of both sexes from the three college of education. Two instruments namely; General Chemistry Misconception Test (GCMT) and General Chemistry Achievement Test (GCAT) were used. The researcher stressed that the application of intervention discussion learning model offered a very good conceptual change strategy for reduction of misconceptions and ensured deep conceptual and meaningful understanding of chemistry concepts. The reviewed work of Ikenne (2014) is closely related to the present study in that both studies discussed the application of conceptual change instructional strategy to remedy the misconception and improve achievement but differ in terms of concepts taught. The reviewed study should have given secondary school a trial to test the effect of this strategy.

Omwirhiren and Ubanwa (2016) investigated the misconception in organic chemistry among senior secondary chemistry students in Zaria Local Government Kaduna state, Nigeria. A total of 120 senior secondary III (SS3) chemistry students with a mean of 17 years were randomly selected from two public single sexed (male and female only) and one private co-educational senior secondary schools in Zaria Local Government Area of Kaduna State. Research question what are the level of misconception of male and female students in organic chemistry was asked and null hypothesis there is no significant difference in the level of misconception between male and female students in organic chemistry was stated. Organic Chemistry Misconception test (OCMT) and a structural questionnaire were used as instrument to collect data. The OCMT contained 30 multiple choice questions with four options (A-D) designed to identify students' misconception while the questionnaire contained 23 questions designed to determine students' awareness and attitude towards organic chemistry. The data was analyzed using frequencies, percentages, mean, standard deviation and t-test statistics at $P<0.05$. The result of the study revealed that students have misconception in organic chemistry and there was no significant difference in the level of misconception between male and female students ($t.cal=0.48 < t.crit=1.96$). There was no significant difference between male or female students' misconception in organic chemistry and their academic performance ($t.cal=0.32 < t.crit=1.96$) and ($t.cal=0.57 < t.crit=1.96$). There was no significant difference between the academic performance of male and female students in organic chemistry ($t.cal=0.57 < t.crit=1.96$). Based on the findings, it was recommended among others that the teaching of organic chemistry should start as early as SS1 so as to allow full coverage of its content and hence familiarize the students with it components. The reviewed work is similar to the present study in that both examined misconceptions in chemistry concepts but the difference is that former was on organic chemistry while the latter is on acids and bases concept. The limitation of the reviewed work is that the study was on private high school and singled sex (male and female). Public schools should have been used or rather the combination of the two (private and public).

All the above studies revealed the prevalence of misconceptions in all subject disciplines among categories of learners and even among teachers and pre-service teachers. This is an indication that all the researchers contended that teachers who are expected to pass the correct knowledge to the learner are themselves harboring misconceptions, which is better treated using Conceptual Change Instructional Strategy. The study therefore is a contributory intervention to improve learners' competence from one hand and enhance the performance of students at Senior Secondary Schools.

## 2.8 Implications of Literature Reviewed on the Present Study

The review into many research studies in the area of misconception, academic performance, conceptual change instructional strategy as well as gender were carried out. Several learning difficulties experienced by students made them have different misconceptions of acid-base concepts that the teachers attempt to put across. In many of the studies reviewed like Pabuccu and Geban (2006), Lawal,(2009) Kaya, (2011) ,Taslidere (2013), Sendur and Toprak(2013) among others have been conducted on the use of conceptual change instructional strategy (CCIS) in correcting misconception and improve students' academic performance. The findings showed that the strategy may help students build conceptual bridges between what they already know and what they are setting out to learn. Also the strategy may help students construct their own knowledge, a process that is encouraged in the standards and consistent with the constructivist view of learning. Although the use of lecture method of teaching was revealed to be of little help for learners to change or alter harbored misconceptions. This has resulted into poor performance among SSI chemistry students. To ensure meaningful learning that is to overcome misconceptions and improved academic performance among learners, several specific instructional strategies that are suitable to bring readiness to the problem have been found in the literature. Such instructional strategies that are gradually gaining research attention of recent are student-centered strategies which include CCIS. From the literature sited, most of the studies carried out CCIS were at pre-service teachers, teachers and SSII. Therefore the research used CCIS at SSI level to determine its effectiveness.

From the literature cited, it shows that studies on misconceptions more especially in acid-base concepts were not carried out at SSI level. Therefore, this study deem to fill in this gap by investigating effects of Conceptual Change Instructional Strategy (CCIS) to teach acids and bases concepts to SSI chemistry students, in order to address the misconception brought into the class and to investigate if the academic performance of the students will be enhanced.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This study investigated the effects of the use of conceptual change instructional strategy for remediating misconceptions in the concepts of acids and bases among senior secondary school chemistry students in Zaria-Education Zone. This chapter examined the methodology that was employed in carrying out the study. The chapter is presented under the following sub-headings;

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Procedure

3.5 Instrumentation

3.5.1 Acids and Bases Misconception Test

3.5.2 Acids and Bases Performance Test

3.5.3 Validation of Instrument

3.6 Pilot Testing

3.6.1 Reliability of Instrument

3.6.2 Item Analysis of Instrument

3.7 Administration of Treatment

3.7.1 Administration of Treatment to the Subjects in Experimental Group

3.7.2 Administration of Treatment to the Subjects in Control Group

3.8 Data Collection Procedure

3.9 Procedure for Data Analysis

## 3.2 Research Design

The design of the study was in two stages; the first stage was survey which involved the identification of misconceptions students harbor about acids and bases concepts using open-ended questions. The purpose of this was to explore, identify and document the description of the students' misconceptions about acids and bases. Consequently, the test results was scored rather the frequencies of occurrences of naïve conception was noted and used as distracters in construction of  the research instrument for the main study, which was the second part of the study.

The second part of the study was quasi experimental which involved pretest, posttest quasi experimental control groups design using ABMT and ABPT respectively. The purpose of using this design agreed with Dahiru (2013) who opined that "experimental design could be used to investigate possible cause and effect as well as relationship between two or more variables by the application of treatment which could not be resolved by observation or description". The experimental and control groups were pretested to determine the group equivalence at the beginning of the study and to ensure that they did not differ significantly in their abilities. Two groups of students were used for the study the experimental and the control groups. The experimental group (EG) was taught using Conceptual Change Instructional Strategy while the control group (CG) was taught using the Lecture Method.

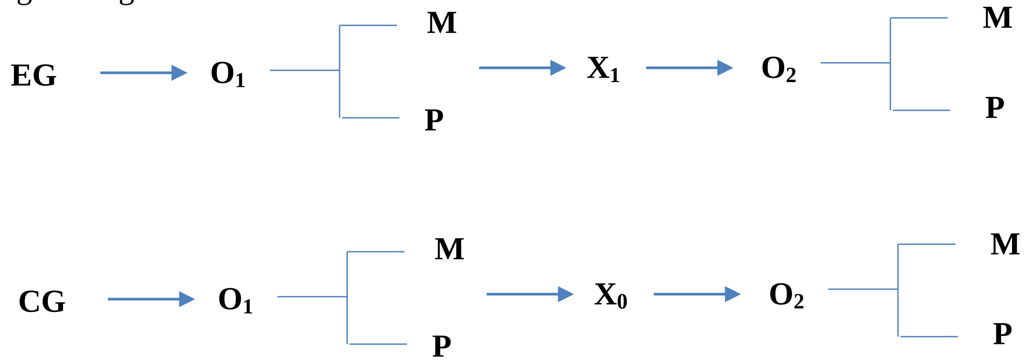



**Figure 3.1: Research Design**

Where:

EG = Experimental group

CG= Control group

$O_1$ = Pretest

$O_2$ = Posttest

$X_o$=Lecture method

$X_1$=Conceptual change Instructional Strategy

P= Performance test (ABPT)

M=Misconception test (ABMT)

## 3.3 Population of the Study

The population of this study comprised all SS 1 chemistry students in Government Senior Secondary Schools in Zaria metropolis. There were a total number of twenty-one schools with a total number of one thousand four hundred and thirty four (1434) SS1 chemistry students made up of 952 males and 482 females. Out of the twenty one (21) schools, seven (7) are single sex (that is either male or female) while fourteen (14) were co-educational (mixed school). Details of the population are given in Table 3.1

**Table 3.1: Population of the Study**

| S/N. | Name of Schools | Status | No of males | No of females | Total |
|---|---|---|---|---|---|
| 1. | G.S.S Zaria (Snr) | Male | 50 | - | 50 |
| 2. | Barewa College (Snr) Zaria | Male | 75 | - | 75 |
| 3. | Alhudahuda college (Snr) Zaria | Male | 95 | - | 95 |
| 4. | Science Sec. School, Kufena | Male | 100 | - | 100 |
| 5. | G.G.S.S (WTC) Zaria | Female | - | 41 | 41 |
| 6. | G.G.S.S Pada (Snr) Zaria | Female | - | 50 | 50 |
| 7. | G.G.S.S K/Gayan Zaria | Female | - | 52 | 52 |
| 8. | G.S.S Magajiya Zaria | co-educational | 26 | 19 | 45 |
| 9. | G.S.S Dakaci Zaria | co-educational | 36 | 20 | 56 |
| 10. | G.S.S Kaura Zaria | co-educational | 23 | 16 | 39 |
| 11. | G.S.S TudunJukun Zaria | co-educational | 41 | 24 | 65 |
| 12. | G.S.S K/Kuyanbana Zaria | co-educational | 47 | 15 | 62 |
| 13. | G.S.S KofanJatau Zaria | co-educational | 33 | 12 | 45 |
| 14. | SF ASSS Karaukarau | co-educational | 12 | 8 | 20 |
| 15. | G.S.S Muchia Snr | co-educational | 72 | 51 | 123 |
| 16. | G.S.S Dinya | co-educational | 8 | 4 | 12 |
| 17. | G.S.S Kugu | co-educational | 16 | 9 | 25 |
| 18. | G.S.S Tundun Sebu | co-educational | 59 | 23 | 82 |
| 19. | G.S.S Yakasai | co-educational | 76 | 55 | 131 |
| 20. | G.S.S Aminu Snr | co-educational | 124 | 58 | 182 |
| 21. | GSS Likoro | co-educational | 57 | 25 | 82 |
| | **Total** | | **952** | **482** | **1434** |

Source: Zaria Inspectorate Division of Kaduna State, (2016)

## 3.4 Sample and Sampling Techniques

From the population, seven (7) co-educational schools were randomly selected. Due to the nature of the study, two categories of samples were selected. The first categories of the sampled students were those required for identification of the misconceptions among students. All the SSI chemistry students from the seven (7) co-educational schools were given Acids and Bases Misconception Test (ABMT). To identify the misconceptions held by students about acids and bases concept, the scripts were marked and scored. A total of 578 students comprising 359 males and 219 females were used for the identification of misconception. ANOVA was employed on scores from the seven (7) schools in the population and Scheffe’s test was used to bring out those schools with higher misconception. Table 3.2 is the distribution of the schools and the number of students in each school.

**Table 3.2: Schools Sampled for Survey on Misconception**

| S/N | Schools | No of Male | No of Female | Total |
|---|---|---|---|---|
| 1. | SF ASSS Karaukarau | 12 | 8 | 20 |
| 2. | G.S.S Yakasai | 76 | 55 | 131 |
| 3. | G.S.S Muchia Snr | 72 | 51 | 123 |
| 4. | G.S.S Aminu Snr | 124 | 58 | 182 |
| 5 | G.S.S Magajiya | 26 | 19 | 45 |
| 6. | G.S.S Dinya | 8 | 4 | 12 |
| 7. | G.S.S Tudun Jukun | 41 | 24 | 65 |
| | **Total** | **359** | **219** | **578** |

Four schools with highest misconception result were selected from the seven (7) schools. These four schools were pretested using Acids and Bases Performance Test (ABPT) before the commencement of the treatment in order to determine their equivalence in ability level. The scores obtained from the pretest, were subjected to Analyses of Variance (ANOVA) and Scheffe's test. Two of those schools found not to differ significantly in their performance scores were chosen and and used for data collection. The decision as to which of the two schools was to be used as the experimental or control group was made by flipping a coin. The tail was slated for experimental group while the head was for the control group. An intact class of 45 students and 65 students was used for experimental and control group respectively.

**Table 3.3: Sample of the Study**

| Group | No. of Students | | Total |
|---|---|---|---|
| | **Males** | **Females** | |
| Experimental | 26 | 19 | 45 |
| Control | 41 | 24 | 65 |
| **Total** | **67** | **43** | **110** |

**Selection of Concept Taught**

The main concept in the study was acids and bases which was a major concept in senior secondary 1 (SS1) curriculum. Achimugu, (2009) confirmed that senior secondary school students have difficulties in learning chemical concepts, such as solubility, electrolysis, redox reaction, acids and bases, chemical equilibrium and balancing of chemical equation. Also, Ozmen et al., (2012) revealed that among the areas students harbor persistent misconceptions include acids and bases. This formed the basis of which acids and bases concepts were selected for the study.

## 3.5 Instrumentation

Two instruments were used to gather data for this study. They were:

a. Acids and Bases Misconception Test (ABMT)

b. Acids and Bases Performance Test (ABPT)

### 3.5.1 Acids and Bases Misconception Test (ABMT)

Acids and Bases Misconception Test (ABMT) was designed in order to identify students' misconceptions on acids and bases. The ABMT was a 20-item test (see Appendix I). The test-items construction adapted a cyclic pattern prescribed by Anderson Sheldon and Dubay (1990) modified by Lawal, (2009) as shown in Fig 3.2.

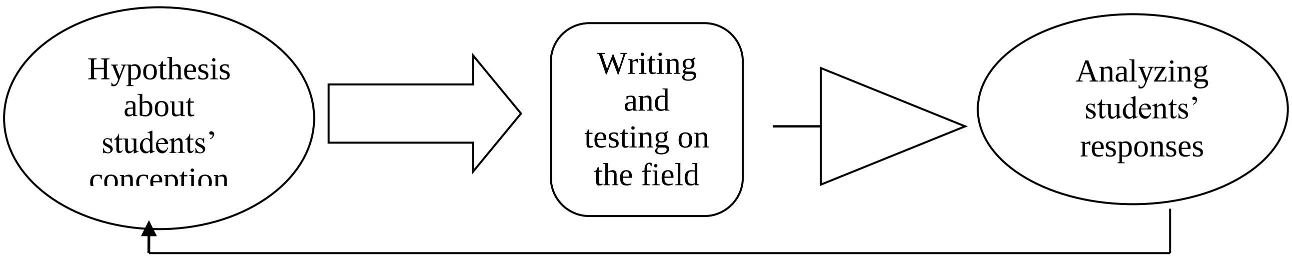



**Figure 3.2: Misconception Test Item Developing Pattern**
Source: Anderson et al (1990).

In constructing the questions, an intelligent guess was first made of the students' conception and questions were then set from hypothesized conceptions. These questions were set to probe into the students' knowledge of the concepts of acids and bases. The answers written out by the students were then marked, scored and analyzed to determine their initial conception of acids and bases. The non-scientific statements formed the misconceptions. These misconceptions were then used as distracters in the construction of the Acids and Bases Performance Test (ABPT)

### 3.5.2 Acids and Bases Performance Test (ABPT)

The Acids and Bases Performance Test (ABPT) items were constructed based on the findings generated from the Acids and Bases Misconception Test (ABMT). ABPT was adapted from New School Chemistry textbook, past National Examination Council (NECO) questions and past West Africa Examination Council (WAEC) questions.

The ABPT consisted of two sections, A and B (Appendix II). Section A sought personal information of the respondents with respect to gender, class, location of school and age, while section B consists of 40 multiple choice test items. Each of the multiple-choice test items was followed by five (5) options from which the students were expected to choose the option that best answers the question. The ABPT was administered to both experimental and control groups as pretest and posttest.

The test item covered all six levels of learning outcomes as specified by Bloom which is presented in the table of specification given in Table 3.3

**Table 3.3: Table of Specification based on Bloom's Taxonomy of Cognitive Level**

| S/N | Topics | Weight | Knowl | Compre | Applic | Analys | Synth | Evaln | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Acids: Basicity of Acids | 20 | 4 | 2 | 2 | - | - | - | 8 |
| 2 | Chemical and physical properties | 15 | 4 | 1 | - | 1 | - | - | 6 |
| 3 | Preparation of acids | 15 | 1 | 1 | - | 1 | - | 3 | 6 |
| 4 | Bases and Alkalis physical and chemical properties and uses | 25 | 4 | 1 | 2 | 1 | 1 | 1 | 10 |
| 5 | Measurement of acidity and alkalinity, pH scale, acid-base indicators | 25 | 2 | 2 | 1 | 2 | - | 3 | 10 |
| | Total | 100 | | | | | | | 40 |

Source: Bloom's Taxonomy (1956)

### 3.5.3 Validity of the Instrument

ABPT and ABMT were given to experts for content as well as face validation. The experts were two senior lectures in the Science Education Department of Ahmadu Bello University, Zaria, and two chemistry teachers in senior secondary school level. The experts were requested to critically examine and asses all the items in the instrument, make constructive criticisms and corrections as well as;

i. Whether the test items tested what they were meant to test.

ii. The appropriateness of the questions for the level of the students for which it is intended.

iii. The possible errors in the suggested answers.

iv. The questions adequately covered the syllabus.

v. The clarity of language and expression.

The experts made constructive criticisms and corrections:

In the ABPT some questions were reframed to suit the purpose of the research, some of the questions were cancelled while some of language expressions were corrected. The questions initially were fifty (50) but after the validation, they were reduced to forty (40).

In ABMT the questions initially were fifty (15) but after the validation, they were increased to twenty (20), some of the questions were cancelled while some of language expressions were corrected which lead to final selection of items and the respective marking scheme was attached.

### 3.6 Pilot Testing

For the purpose of pilot test, SS1 students of G.S.S Kofan kuyanbana participated in the pilot testing of the instruments. The school chosen was part of the population but not one of those identified to be used for the main study. A sample of 62 students made up of 47 males and 15 females was used to pilot test Acids and Bases Misconception Test (ABMT) and Acids and Bases Performance Test (ABPT) all in the same school. With the pilot test, the researcher was able to determine the appropriate duration for each test, assess the clarity of the items of the ABMT and ABPT, as well as identify the problem which might affect the effective administration of the instruments during the actual experiment. The characteristics of the test item which included the facility and discrimination indices and the reliability coefficient were also determined.

#### 3.6.1 Reliability of the Instrument

Reliability is the degree of error or precision in which an instrument measures what is supposed to measure. The score obtained from the pilot study were used to determine the reliability coefficient of ABPT. The study employed test re-test method on the scores obtained from the pilot study two weeks after the administration of ABPT it was re-administered to the students again as proposed by Tuckman, (1975) and Sambo, (2008). Pearson Product Moment Correlation Coefficient (PPMCC) was used to determine the Reliability Coefficient of both ABMT and ABPT. The reliability coefficient of ABMT was found to be r = 0.68 which shows that the reliability of the instrument is high and could be used for data collection for the study while the reliability coefficient of ABPT for this study was found to be r = 0.78 which showed that the reliability of the instrument was high and was used for data collection for the study.

### 3.6.2 Item Analysis

Item analysis was carried out on the results of the Acids and Bases concepts Performance Test (ABPT) to determine the Facility Index (FI) and Discrimination Index (DI) of the items. They are derived as follows:

**Facility Index**: facility index according to Wood (1990) is the percentage of students who obtained the correct answer on an item which is determined by the formula

$$FI = \frac{R}{T}$$

Where: R = Number of correct responses.

T = Total number of students.

For this study, 0.30 to 0.89 was chosen providing a wide range of difficulty items. This is line with Sambo (2008) and Ozmen et al (2012) who recommended values within the range of 0.30 to 0.89 for good items value in assessing performance.

**Discrimination Index (DI)**: Discrimination index of a test refer to the capacity of such test to discriminate or distinguish between high and low achievers among students in a sample. If an item has positive discrimination index, it implies that large proportion of the more competent students than poor ones got the item right. If the value is zero, the item has zero discrimination, which means that the items are unable to distinguish between the competent and incompetent students. The negative value of discrimination index indicates that more of the poorer students got the item right compare to the competent ones. Mehrens and Lehmann (1984) stressed that the higher the discrimination indices the better, recognizing that there are situations where low discrimination indices is to be expected. e.g. classroom test. Furst, (1958) stated that discrimination indices which range from 0.30 to 0.70 are described as moderately positive and above this are highly positive. Therefore, the recommended value within these range are regarded as good test item values in assessing performance.

The discrimination index was calculated using the formula given by (Furst, in Olorukooba, 2001)

$$DI = \frac{R_u - R_L}{\frac{1}{2}N}$$

Where:
DI = discrimination index

$R_U$ = number of upper 27% of respondents

$R_L$ = number of lower 27% of respondents

N = total number of respondents

As earlier stated, the magnitude of discrimination indices which range from 0.30 to 0.70 was used as in line with Lawal (2009). (Appendix IV)

### 3.7 Administration of the Treatment

Two major treatments were given to the groups. The experimental group was taught using conceptual change instructional strategy while the control group was taught using lecture method

#### 3.7.1 Administration of the Treatment to the Subjects in Experimental Group

The subjects in the experimental group were exposed to Conceptual Change Instructional Strategy CCIS which was the remedial package for the study. The acids and bases concepts were taught using the CCIS. The teaching of the concept was done by the researcher. The aim was to make effective utilization of the model and to ensure that the teaching procedure was in accordance with the direction of the model, it was also used to be able to remove any teacher bias that might rise.

Posner et al (1982), model comprised the following steps:

a. Students' preconceptions.

b. Increasing inconsistencies of preconceptions.

c. Dissatisfaction with preconceptions

d. Turning to new scientific conception which must be: intelligible, plausible and fruitful to allow for;

e. A shift from preconception to new scientific conception which will lead to;

f. Accommodation of new scientifically validated conceptions.

Lawal (2009), modified the strategy by organizing the strategy into five-phases teaching sequence instead of the six phases proposed by Posner et .al; i.e the first two steps were merged as one instead of the six phases initiated by Posner et al. However the present study adopted the modified model which used the five phases as follows;

a. Awareness or orientation phase.

b. Disequilibrium or Elicitation of ideas Phase.

c. Reformation Phase.

d. Application Phase.

e. Evaluation Phase.

The lesson plans was written based on this model and a description of each of the five stages buttressed, thus:

A. Awareness or Orientation Phase:

At the beginning of each awareness phase, it emanates clear clarification which aimed at making the learner to recognize the existence of conflict in the pre-conception of the subject matter. At this stage, the following measures were taken:

i. Students were asked questions from the pretest and were allowed to respond on their own in their group discussions. They freely made their clear conceptions as much as possible.

ii. Their exploration focused on the questions raised. These questions guided students to observe and discuss their conceptions which might be contrary to what they already believed: that could lead to "cognitive conflict".

B. Disequilibrium or Elicitation of ideas Phase:

The process of students' explorations led to students encountering new information.

This led to state of disequilibrium (dissatisfaction). More brainstorming questions were made and some theoretical explanations were offered to the students.

C. Reformation Phase:

The teacher intervened and reduced students conflicting situation by reinforcing the appropriate conceptions. New conceptions were discussed and their previous conceptions were written on the board, thus making the existing conceptions plausible. More explanations and examples brought up major re-conceptualization, hence modifying students' ideas. Here the teacher facilitated with provision of relevant information and questions needed to lead students thinking.

D. Application Phase:

At this level, students were saturated they were capable of giving outright explanations and examples of the phenomenon using the new conceptions, solved some problems or gave examples of phenomena in their present real life situation.

E. Evaluation Phase:

At this stage, students made comparisons from initial ideas with the current one. Also, the status of the new constructed ideas is been determined. But, it is important to note that these developments are not in series. Sometimes, the misconceptions might be elicited at reformative stage, disequilibrium or even awareness stage as the students responded to questions.

The experimental groups were exposed to the treatment using the Conceptual Change Instructional Strategy. This basically involved students' individual presentations and discussions. Each session started with brainstorming questions aimed at eliciting and highlighting the existence and nature of viewpoints. The subjects were allowed to explore the concepts in question through small group discussions. In the exploration session, they were asked focusing questions meant to lead them to observe and discuss their experiences.

Discrepant ideas stimulated the students to articulate inconsistencies and discrepancies between the phenomenon in question and their own previous held ideas. Time was allowed for the students to discuss, and answer questions from other groups. Important decisions were written down by each group. Correct theoretical explanations resulting from the discussions were written by the teacher on the side of the chalkboard for emphasis. The aim was to reinforce appropriate conceptions and possibly shift or change students' earlier misconceptions.

The researcher harmonized the correct conceptions from her own investigations and the results of students' presentations. The students were then asked to compare their previously held views with the correct views, criticizing thoroughly as written out on the chalkboard. They were also asked to suggest alternative explanations and compare them with their previous ideas. The new ideas were then tested against accepted ideas and their thinking sharpened towards descriptions to help bring about re-conceptualization. The students will be given exercises to help determine the status of their newly constructed conceptions. All these processes were vividly demonstrated in the modified model in Figure 3.4.

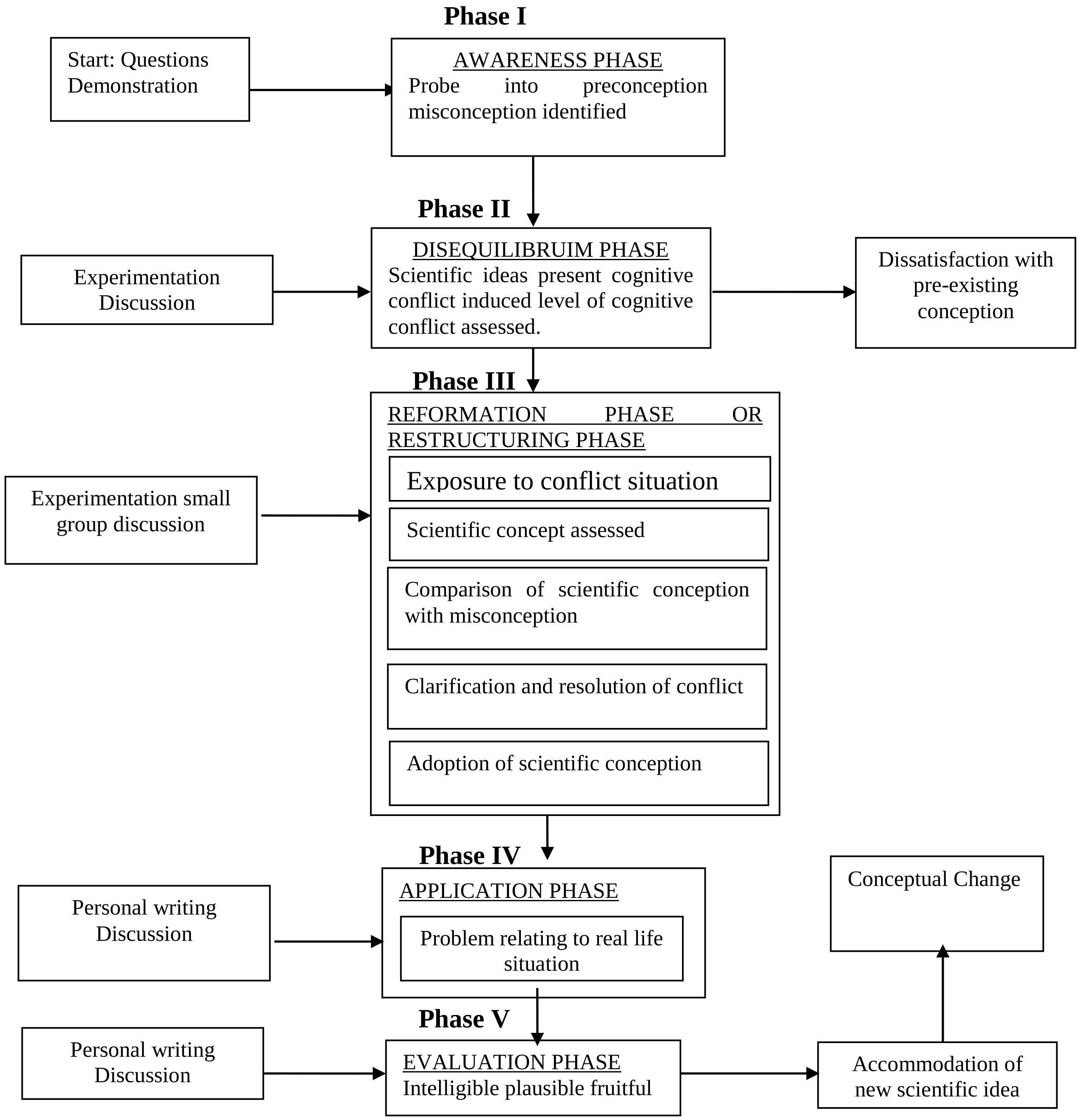



**Figure 3.4: A Flowchart of Conceptual Change Instructional Strategy used for the Study (A Remediation Package)**

Source: Modified from Posner et al (2016)

### 3.7.2 Administration of the Treatment to the Subjects in Control Group

The control group was taught the same concepts using the lecture method for the same duration. The note of lessons prepared by researcher was strictly adhered to in teaching of the subjects in the control group. The concepts were discussed and explained verbally using talk and chalk, students wrote notes where necessary and asked questions where they find difficult to understand.

During the teaching period, the teacher stopped to display, drawn and show any necessary materials on the topics as teaching aid where the need aroused. The subjects were referred to chemistry text books for more information. Written assignments were given to the subjects after each lesson. The entire teaching will lasted for the period of six weeks.

## 3.8 Data Collection Procedure

Acids and Bases Misconception Test (ABMT) and Acids and Bases Performance Test (ABPT) were administered at the beginning of the exercise as pretest. The purpose of Acids and Bases Misconception Test (ABMT) was to explore, identify and document the description of students' misconceptions about acid and base concept. Consequently, the test results were scored, the frequencies of occurrence of the naïve conceptions were noted and used as distractors in the construction of Acids and Bases Performance Test (ABPT). Furthermore, the misconceptions were classified according to their types. However, in Acids and Bases Performance Test (ABPT) each item was scored one point, with the maximum point being 40 marks. The scores of the pretest were analyzed to determine if there is any significant difference in the performance of the students in experimental and control groups. There-after, the two groups were taught the same chemistry concept (acids and bases) by the researcher. The control group was taught using lecture method while the experimental group was taught using conceptual change instructional strategy. After a period of six weeks of treatment, a posttest was administered to both subjects in the experimental and control groups with ABMT and ABPT. The instruments were scored using the carefully prepared and validated marking guide to ensure uniformity in scoring. The performance and degree of misconceptions held prior to and after the instruction were compared based on the scores obtained. Gender related differences were also computed within and between the groups. The research instruments were personally administered by the researcher after which the results were subjected to data analysis.

### 3.9 Procedure for Data Analysis

The results and responses of the subjects obtained from the two instruments were scored using the marking guide for each instrument respectively, and the data collected was analyzed by re-stating the research questions and null hypotheses, while appropriate statistical tools were used for the stated hypotheses at $P \leq 0.05$ level of significance to retain or reject the null hypotheses.

#### 3.9.1 Research Questions

The stated research questions for this study were analyzed using mean and standard deviation while research question one was analyzed using frequency count and percentage.

#### 3.9.2 Null Hypotheses

The following research hypotheses were formulated for testing at $p \leq 0.05$.

$HO_1$: There is no significant difference in the misconception mean scores in the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method.

This hypothesis was analyzed using t-test (since there are two groups and it is an interval scale)

$HO_2$: There is no significant difference in the in the misconception mean scores in acids and bases concept of male and female students taught using CCIS and those taught using lecture method.

This hypothesis was analyzed using t-test (since there are two groups and it is an interval scale)

$HO_3$: There is no significant difference between the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction.

This hypothesis was analyzed using t-test (since there are two groups and it is an interval scale)

$HO_4$: There is no significant difference in academic performance of male and female chemistry students taught using conceptual change instructional strategy.

This hypothesis was analyzed using t-test (since there are two groups and it is an interval scale)

# CHAPTER FOUR

# DATA ANALYSIS, RESULTS AND DISCUSSION

## 4.1 Introduction

The aim of the study was to investigate effects of conceptual change instructional strategy in remediating misconceptions in the concepts of acids and bases among senior secondary school chemistry students in Zaria Education-zone. This chapter contained the description of data analysis, results, summary of findings and discussion. The data were analyzed using the Statistical Package for Social Sciences (SPSS).The level of significance adopted for the study was 0.05. This level of significance formed the basis for retaining or rejecting the null hypotheses.

The chapter was discussed under the following subsections:

4.2 Data Analysis and Result Presentation

4.3 Hypotheses Testing

4.4 Summary of Major Findings

4.5 Discussion of Results

## 4.2 Data Analysis and Result Presentation

In this study, five research questions and four hypotheses were formulated for to guide the study. Two instruments used for data collection were:

i. Acids and Bases Misconception Test (ABMT)

ii. Acids and Bases Performance Test (ABPT)

### 4.2.1 Answering Research Questions

For the purpose of answering research questions, the data collected were used to answer the following questions:

**Research Question One:** What are the types of acids and bases misconceptions held by SS I chemistry students?

To answer research question one, frequency count and percentages were used on the type of misconceptions students held both at pretest and posttest. The results of the analysis are presented in Table 4.1.

**Table 4.1: Categories and Frequency of Identified Misconceptions**

| S/N | Type of misconceptions | Pretest | | Posttest | |
|---|---|---|---|---|---|
| | | Frequency | Percentage | Frequency | Percentage |
| 1. | Preconceived notions | 17 | 68.00% | 2 | 8.00% |
| 2. | Factual misconceptions | 4 | 16.00% | - | - |
| 3. | Conceptual misunderstandings | 3 | 12.00% | - | - |
| 4. | Non-scientific believes | 1 | 4.00% | - | - |
| | Total | 25 | 100.00% | | 8.00% |

From the result in Table 4.1 the most frequent misconception held by the students in pretest was preconceived notion with 17 (68.00%) followed by factual misconception with 4 (16.00%). The third high percentage misconception held by the students was on conceptual misunderstanding with 3 (12.00%) while the misconception with the lowest percentage was Non-scientific belief with 1(4.00%). Consequently, it was determined that in the posttest the only existing misconception was preconceived notion with 2(8.00%) the others were removed completely. (Appendix VI and VII).

**Research Question Two:** What is the difference in the misconception mean scores in concepts of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method?

Descriptive statistics of mean and standard deviation of misconception mean scores were used to answer the research questions. The results of the analysis are presented in Table 4.2.

**Table 4.2: Mean Performance Posttest Misconception Scores of Students Exposed to Conceptual Change Instructional Strategy and Lecture Method**

| Grouping | N | Mean | Std. Dev. | Std. Error | Mean Difference |
|---|---|---|---|---|---|
| Experimental | 45 | 13.00 | 3.09 | 0.46 | 2.94 |
| Control | 65 | 10.06 | 2.50 | 0.31 | |

Table 4.2 shows the difference in the mean scores for misconception of students taught using conceptual change instructional strategy and lecture method was (2.94) in favor of students exposed to conceptual change instructional strategy. That is, Chemistry students taught using conceptual change instructional strategy had higher scores with mean and standard deviation of 13.00 and 3.09 as compared to those taught using lecture method 10.06 and 2.50. The mean scores for misconception of Chemistry students were different. In order to test if the difference is significant, hypothesis one was tested using t-test statistics.

**Research Question Three:** What is the difference in the misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method?

Descriptive statistics of mean and standard deviation were used to answer the research question three. The result of the analysis is presented in Table 4.3.

**Table 4.3: Misconception Mean Scores of Male and Female Students in the Experimental and Control Groups**

| Treatment | Gender | Mean | Std. Error | Mean difference |
|---|---|---|---|---|
| Experimental Group (CCIS) | Male | 21.043[a] | .706 | 3.85 |
| | Female | 24.891[a] | .826 | |
| Control Group (Lecture) | Male | 17.873[a] | .562 | 0.14 |
| | Female | 18.006[a] | .735 | |

Result in Table 4.3 shows that differences exist in the mean scores of male and female students when taught using Conceptual Change Instructional Strategy and those taught with lecture method. The difference between male and female in Conceptual Change Instructional Strategy group is 3.85 in favor of female students. The Table also revealed that female students also performed better than male students taught using lecture method. In order to determine whether the difference is statistically significant or is just by chance, a 2-Way Analysis of Covariance (ANCOVA) was used to find the difference.

**Research Question Four**

What is the difference between the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction?

Descriptive statistics of mean and standard deviation were used on the posttest scores to answer the research question. The results of the analysis are presented in Table 4.4.

**Table 4.4: Mean and Standard Deviation of Posttest Scores for Experimental and Control Groups**

| Grouping | N | Mean | Std. Dev. | Std. Error | Mean Difference |
|---|---|---|---|---|---|
| Experimental | 45 | 41.64 | 5.61 | 0.84 | 7.88 |
| Control | 65 | 33.76 | 3.22 | 0.48 | |

Results from Table 4.4 shows that the computed performance mean scores of the experimental and control groups are 41.64 and 33.76 respectively with a mean difference of 7.88 in favor of the experimental group. This means that the experimental group students performed better than the control group students. This can be attributed to the treatment (the use of conceptual change instructional strategy) given. This is an indication that the use of conceptual change instructional strategy has positive effects on chemistry students' academic performance in acids and bases concepts. In order to test if the difference is significant, hypotheses three was tested using t-test statistics.

**Research Question Five**

What is the difference in academic performance of male and female chemistry students taught using conceptual change instructional strategy?

Descriptive statistics of mean and standard deviation were used to answer the research question. The results of the analysis are presented in Table 4.5.

**Table 4.5: Mean and Standard Deviation of Posttest Scores for Male and Female Chemistry Students in the Experimental Group**

| Gender | N | Mean | Std. Dev. | Std. Error | Mean Difference |
|---|---|---|---|---|---|
| Male | 26 | 38.65 | 4.13 | 0.81 | 7.09 |
| Female | 19 | 45.74 | 4.77 | 1.09 | |

Results from Table 4.5 shows that the computed performances mean scores for male and female students in the experimental group are 41.64 and 33.76 respectively with a mean difference of 7.09 in favor of the female students. This means that the female students performed better than their male counterparts. This is an indication that the use of conceptual change instructional strategy has positive effects on female chemistry students' academic performance in acids and bases concepts more than the male students. In order to test if the difference is significant, hypotheses four was tested using t-test statistics.

### 4.2.2 Null Hypotheses Testing

**Null Hypothesis One:** There is no significant difference in the misconception mean scores of the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method.

In order to test hypothesis one, the posttest misconception scores on ABMT of students were subjected to t-test at $p \leq 0.05$ level of significance. The result of the analysis is shown in Table 4.6.

**Table 4.6: t-test Analysis for Posttest Misconception Scores of Students in the Experimental and Control Groups**

| Groups | N | Mean | SD | Df | t-cal | p-value | Remark |
|---|---|---|---|---|---|---|---|
| **Experimental** | 45 | 13.0 | 3.09 | 108 | 5.50 | 0.001 | Sig. |
| **Control** | 65 | 10.06 | 2.50 | | | | |

Significant $p \leq 0.05$

Table 4.6 revealed that the independent sample t-test showed that the difference in misconception scores between the experimental group (N = 45, M = 13.0, SD = 3.09) and the control group (N = 65, M = 10.06, SD = 2.50) were statistically significant. The calculated t-value is 5.50 and p-value is 0.001. The p-value of 0.001 is less than alpha value of 0.05. Based on this evidence, the null hypothesis which states that there is no significant differences in the misconception mean scores in Acids and base concepts among SS I Chemistry students taught using CCIS and those taught using lecture method is therefore, rejected.

**Null Hypothesis Two:** There is no significant difference in misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method.

A 2-way Analysis of Covariance (ANCOVA) was conducted to test the null hypothesis at $p \leq 0.05$ level of significance. The result of the analysis is displayed in Table 4.7.

**Table 4.7: Two-Way Analysis of Covariance (ANCOVA) of misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 762.557[a] | 4 | 190.639 | 14.714 | .000 |
| Intercept | 5182.338 | 1 | 5182.338 | 399.990 | .000 |
| Pretest | .744 | 1 | .744 | .057 | .811 |
| Treatment | 643.205 | 1 | 643.205 | 49.645 | .000 |
| Gender | 100.824 | 1 | 100.824 | 7.782 | .006 |
| Treatment * Gender | 87.481 | 1 | 87.481 | 6.752 | .011 |
| Error | 1360.397 | 105 | 12.956 | | |
| Total | 45525.000 | 110 | | | |
| Corrected Total | 2122.955 | 109 | | | |

a. R Squared = .359 (Adjusted R Squared = .335)

Table 4.7 shows the Summary of 2-Way Analysis of Covariance (ANCOVA) of misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method. The table shows that there is a significant difference in the misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method $F(1,105) = 6.75$, $p = 0.01$ (less than .05 alpha level of significance). As a result of this, the null hypothesis which states that there is no significant difference in misconception mean scores in acids and bases concepts of male and female students taught using CCIS and those taught using lecture method is therefore rejected.

**Null Hypothesis Three:** There is no significant difference in the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction.

Academic Performance in chemistry of students taught using conceptual change instructional strategy (experimental group) and those taught using lecture method (control group) were compared to test if the differences obtained in Table 4.3 is significant. t-test statistics was used to test the null hypothesis at $p \leq 0.05$ level of significance. The result of the analysis is shown in Table 4.8.

**Table 4.8: t-test Analysis for Posttest Scores of Students in the Experimental and Control Groups**

| Groups | N | Mean | SD | Df | t-cal | p-value | Remark |
|---|---|---|---|---|---|---|---|
| **Experimental** | 45 | 41.64 | 5.61 | 108 | 10.12 | 0.001 | Sig. |
| **Control** | 65 | 33.17 | 3.13 | | | | |

Significant $p \leq 0.05$

Table 4.8 revealed that the independent sample t-test showed that the difference in performance scores between the experimental group (N = 45, M = 41.64, SD = 5.61) and the control group (N = 65, M = 33.17, SD = 3.13) were statistically significant. The calculated t-value is 10.12 and p-value is 0.001. The p-value of 0.001 is less than alpha value of 0.05. Based on this evidence, the null hypothesis which states that there is no significant difference in the academic performance of students taught acids and bases concepts using conceptual change instructional strategy and those taught using lecture method of instruction is therefore, rejected.

**Null Hypothesis Four:** There is no significant difference in academic performance between male and female chemistry students taught using conceptual change instructional strategy.

Academic Performance in chemistry of male and female students taught using conceptual change instructional strategy were compared to test if the differences obtained in Table 4.9 is significant. t-test statistics was used to test the null hypothesis at $p \leq 0.05$ level of significance. The result of the analysis is displayed in Table 4.9.

**Table 4.9: t-test Analysis for Posttest Scores of Male and Female Students in the Experimental Group**

| Gender | N | Mean | SD | Df | t-cal | p-value | Remark |
|---|---|---|---|---|---|---|---|
| **Male** | 26 | 38.65 | 4.13 | 43 | 5.32 | 0.001 | Sig. |
| **Female** | 19 | 45.74 | 4.77 | | | | |

Significant $p \leq 0.05$

Table 4.9 revealed that the independent sample t-test showed that the difference in performance scores between the males students in the experimental group (N = 26, M = 38.65, SD = 4.13) and the female students in the experimental group (N = 19, M = 45.74, SD = 4.77) were statistically significant. The calculated t-value is 5.32 and p-value is 0.001. The p-value of 0.001 is less than alpha value of 0.05. Based on this evidence, the null hypothesis which states that there is no significant difference in academic performance between male and female chemistry students taught using conceptual change instructional strategy is therefore, rejected.

## 4.4 Major Findings

The following findings were established:

1. Four types of misconceptions were identified in acids and bases concepts. The result from the frequency showed that preconceived notion had the major occurring misconceptions while non-scientific belief had the least occurring type of misconception.
2. A significant difference exists between the misconception mean scores of the concept of acids and bases among SS I Chemistry students taught using CCIS and those taught using lecture method
3. A significant difference exists between the misconception mean scores in acids and bases concepts of male and female students taught using conceptual change instructional strategy and those taught using lecture method.
4. Chemistry students taught using conceptual change instructional strategy performed significantly better than those taught using lecture method.
5. Male chemistry students taught using conceptual change instructional strategy did not performed better than female chemistry students taught using conceptual change instructional strategy.

## 4.5 Discussion of Results

The objectives of the study were to identify misconceptions and find out the effect of CCIS on academic performance in acids and bases concepts among SSI chemistry students. The study also aimed at finding out whether the misconceptions could be overcome using Conceptual Change Instructional Strategy.

Table 4.1 shows the frequency and percentage misconception held by SS1 students in acid base concepts. The most frequent misconception held by the students in pretest was preconceived notion with 17 (68.00%) followed by factual misconception with 4 (16.00%). The third high percentage misconception held by the students was on conceptual misunderstanding with 3 (12.00%) while the misconception with the lowest percentage was Non-scientific belief with 1(4.00%). Consequently, it was determined that in the posttest the only existing misconception was preconceived notion with 2(8.00%) the others were removed completely. Moreover, considering the frequency and percentage of students harboring various misconceptions after their respective instruction (Appendix IV), it could be realized that students at the control group consistently had more misconceptions than their counterparts in the experimental group. This result is consistent with that of Metin (20I3) who studied CCIS on pre-service teachers and have a clear evidence of change in misconceived ideas for most pre-service teacher. Further analysis in Table 4.6 showed that students having misconception after being taught using CCIS was significantly reduced. This brings to focus the fact that conceptual change instructional strategy is more effective in remediating misconceptions than lecture method.

Table 4.8 shows the summary of t-test on the mean performance posttest scores of students taught using conceptual change instructional strategy and lecture method. The Table revealed that there is significant differences in the academic performance mean scores of students in experimental group compare to those in control group (t-cal.10.12> 1.98 t-crit.).This implied that the two groups were equivalent in terms of prior knowledge on acids and bases concepts at the point the investigation commenced. However, after treatment (Table 4.8) showed that the experimental group performed significantly better than the control group though the performance of students both groups improved significantly after their respective instruction. One may deduce from the result that the conceptual change instructional strategy was more effective than lecture method of instruction in improving students understanding of acids and bases concepts. It is also noted that even though CCIS was used for the first time and within a limited period of time, the students from the experimental group still performed significantly better than those of the control group. This means that conceptual change instructional strategy actually facilitated students understanding of the concept more compared lecture method. The superior performance achieved through CCIS is in agreement with earlier findings of (Lawal, 2009, Bhim, and Aniruddha, 2013).

Also, the significant difference in the academic performance of males and females chemistry students exposed to Conceptual Change Instructional Strategy was determined. The result in Table 9 indicated that the academic performance of male students was not significantly different from the academic performance of female students. Geban, (2012) and Garnett (2016) revealed that result of the effects of Conceptual Change Instructional Strategy on academic performance of students in terms of gender has not been consistent. The result recorded that Conceptual Change Instructional Strategy had the same effect on academic performance of male and female students exposed to it irrespective of their sex. It means that Conceptual Change Instructional Strategy is gender friendly. The finding of this study is in support of the studies of Harizal, (2012) and Jodi, (2010) who separately concluded that, the academic performance of male and female chemistry students exposed to Conceptual Change Instructional Strategy was not significantly different. Also Modaic, (2011) and Kaya,(2011) conducted their study on the effect of Conceptual Change Instructional Strategy on academic performance of students. They reported no significant difference in the academic performance of male and female students exposed to Conceptual Change Instructional Strategy. The strategy provided equal opportunity to both male and female students to share ideas, benefit one another in order to attain common goals.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Introduction

In this chapter, the summary of the research on the effects of the use of conceptual change instructional strategy in remediating misconceptions in the concepts of acids and bases among senior secondary school chemistry students in Zaria metropolis. The chapter is presented under the following subheadings.

5.2 Summary of the Study

5.3 Summary of Major Findings

5.4 Conclusion

5.5 Recommendations

5.6 Contribution to Knowledge

5.7 Limitations of the Study

5.8 Suggestion for Further Studies

## 5.2 Summary

The study was conducted to find out common misconceptions students hold about concepts in acids and bases and the effect of conceptual change instructional strategy on misconceptions and performance towards acids and bases concepts at senior secondary school level in Zaria education-zone. An adopted teaching strategy of Posner et al (1982) model modified by Lawal (2009) were used to correct misconception that SSI chemistry students held about acids and bases concepts. Also, CCIS was used in experimental group while lecture method was used in control group: the study had five objectives, five research question and four hypotheses. Related literatures were reviewed which provided the basis for the existing information about the problem of the study.

The study was in two parts; the first was a survey to identify the misconceptions students harbor about the concepts acids and bases. 578 SSI chemistry students were drawn from seven (7) co-educational schools and were used for survey. The second part of the study involved using CCIS to teach the experimental group and lecture method to teach the control group. A total of 110 chemistry students were used for data collection for the second part of the study.

The concepts selected for the study were acids and bases. Acids and Bases Misconception Test (ABMT) used made up of twenty (20) short answer questions used to identify misconceptions SSI chemistry students harbor about acids and bases concepts. Based on the identified misconceived ideas, Acids and Bases Performance Test (ABPT) was developed which made up of 40 multiple-choice test items. Before the treatment, the two groups were pretested using Acids and Bases Performance Test (ABPT) to determine the equivalence of the two groups in their ability level. The two groups were taught acids and bases concepts for the period of six weeks. Experimental group was taught using CCIS while the control group was taught using lecture method. After treatment both Acids and Bases Misconception Test (ABMT) and Acids and Bases Performance Test (ABPT) were administered. The data was collected and analyzed using descriptive statistic, t-test statistics to answer the stated research questions and test the null hypotheses. The result and discussions were reported in chapter four. Summary, conclusions and recommendations were presented in chapter five. This study suggested the need for further research in this direction for more collaboration

## 5.3 Summary of Findings

The major findings of the study are summarized below:

1. Four types of misconceptions were identified in the concept of acids and bases concepts. The result from the frequency showed that preconceived notion had the major occurring misconceptions while non-scientific belief had the least occurring type of misconception.
2. A significant difference exists between the misconception mean scores in acids and bases concepts of chemistry students exposed to conceptual change instructional strategy and those exposed to lecture method of instruction.
3. A significant difference exists between the misconception mean scores in acids and bases concepts of male and female students taught using conceptual change instructional strategy and those taught using lecture method.
4. Chemistry students taught using conceptual change instructional strategy performed significantly better than those taught using lecture method.
5. Male chemistry students taught using conceptual change instructional strategy did not performed better than female chemistry students taught using conceptual change instructional strategy.

## 5.4 Conclusion

Based on the findings of this study, the following conclusions were made:

1. Students entering SSI chemistry class come in with misconceived ideas on acids and bases concepts
2. The conceptual change instructional strategy effectively shifted misconception, enhanced understanding of concepts and subsequently this improved performance more than lecture method.

## 5.5 Recommendations

Based on the findings of this study, the following recommendations were made:

1. Considering the research findings, teachers should endeavor to make conscious effort before planning such lessons by questioning or open ended questions to probe into the students prior knowledge on any topic that is about to be taught.
2. For effective instruction, chemistry teachers in secondary schools should employ the use of conceptual change instructional strategy because of its impact on students' academic performance.
3. Conceptual change instructional strategy is not gender friendly, chemistry teachers should put extra effort when using it to eradicate gender differences among science students.

## 5.6 Contributions to Knowledge

The results of the findings of this study have made the following contributions to knowledge.

1. This study was able to identify and classify the types of acids and bases misconceptions among SS I Chemistry students in Zaria Education Zone.
2. The Conceptual Change Instructional Strategy package has helped students shift misconceptions in acids and bases concepts which in turn enhanced performance in Chemistry among secondary school students in Zaria education zone.
3. The Acids and Bases Performance Test (ABPT) instrument was developed by the researcher using Bloom's cognitive taxonomy for the purpose of improving students' performance in acids and bases concepts
4. Using CCIS to remediate misconceptions in acid-base concepts at SSI level has contributed to existing body of knowledge in this area of study.

## 5.7 Limitations of the Study

This study was limited to the following

1. The schools used for this study were secondary schools Zaria education-zone in Kaduna, Nigeria. This restricts down the scope of generalizations of findings to cover secondary schools in Nigeria.
2. The conclusions reached about the effect of conceptual change instructional strategy in this study is only limited to acids and bases concepts.

## 5.8 Suggestions for Further Studies

The following suggestions are made to further expand the scope of the study.

1. Focusing on the teaching of other subjects using CCIS with a view of finding out if similar or different result might be obtained.
2. The replication of the study in other local government in Kaduna state and other states in Nigeria to increase the scope of the generalization
3. The present study used subjects at SSI level only. It is suggested that similar studies should be replicated at Universities, Polytechnics and other Colleges of Education to obtain a more comprehensive and generalizable outcome on the study topic.
4. The effect of the strategy over a long period.

## References


Ababio, O (2005). *New School Chemistry Schools*, Africana First Publishers Limited.

Abduraheem, B.O. (2012). Gender Differences and Students Academic Achievement and Retention in Social Studies among Junior Secondary Schools in Ekiti State. *European journal of educational studies 4 (1), 23-42*

Abuzer, A. (2009). The Relation Between Science Student Teachers Misconception About Solution, dissolution, diffusion and their attitudes towards science with their achievement. *Education and Science*, 34(154), 26.

Achimugu, L. (2009). Calculation in Senior Secondary School, Chemistry, Idah, It System Work.

Adamu, A.S, Boris O.O. &Kenni, A.X (2013). Trends in Students' Achievement in Senior Secondary School Certificate Examination (SSCE) in Chemistry between 2008-2012. *International Journal of Science and Research India online.*

Adesoji, F.A. (2008). Student, Teacher and School Environmental Factors and Determinants ofAchievement in Senior Secondary School Chemistry in Oyo State, Nigeria.*Journal of International Social Research*, (2) 5-16.

Akpan, E.U.U (2005). Issues of Qualitative Analysis in SSCE Chemistry Paper Guidance for Improving Students' Performance.*Paper Presented at a Refresher Course for SecondarySchool Chemistry Teachers by Chemical Society of Nigeria Jos chapter.*11-12, Nov.

Alake, E. (2015). Efficacy of Laboratory Instructional Strategy on Students' Geometry Performance, Retention and Attitude among Junior Secondary School Students of Kaduna State, Nigeria. *Unpublished M.Ed Dissertation*, *Department of Science Education, Ahmadu Bello University, Zaria.*

Ameh,P.O. & Dantani, Y.S.(2012). Effects of Lecture and Demonstration Methods on theAcademic Achievement of Students in Chemistry in Nassarawa Local Government Area of Kano State. *International Journal of Modern Social Sciences* 1(1),29-37.

Anderson, C.W; Sheldon, T.H. and Dubay, J. (1990).The Effects of Instruction on College Non- Major Conceptions of Respiration and Photosynthesis.*Journal of Research in Science Teaching.* 27, 761-776.

Ausubel, D. P. (1968). Educational psychology: A cognitive view. New York: Holt Rinehart, andWinston, Inc.

Aydin,S (2012). Remediation of Misconceptions about Geometric Optics using Conceptual Change Texts.*Journal of Education Research and Behavioral Sciences.*1(1), 001-012, Bhim, C.M. and Aniruddha, C. (2013). Misconceptions in Chemistry: *Its Identification andRemedial Measures.*Lap LAMBERT academic publishing.

Blair, G.M. (2005).*Educational psychology.* London:The Macmillan company

Bloom, B.S. (1956).*Taxonomy of Educational Objectives*: Classification of Educational Goals.Handbook 1: Cognitive Domain. New York: David Mckak Co.

Bugaji B.M. (2010), *Analysis of Students Achievement towards the Three Categories of Questions in Practical Chemistry.* A Paper Presented At The School Of Sciences National Conference Federal College Of Education 12th – 16th May, 2010.

Bunkure, Y.I. (2007) Effect of Computer Assisted Instruction on Student's AcademicAchievement in Physics Among NCE II Student in Kano State. Unpublished Msc. (Ed) thesis Department of Science Education A.B.U. Zaria

Canpolat, N. (2006). The Conceptual Change Approach to Teaching Chemical Equilibrium.*Research in Science &Technological Education,* 24(2), 217 – 235.

Cetingul, P. &Geban, O. (2011).Understanding of Acid-base Concept by Using Conceptual Change Approach.*Hacettepe University Journal of Education*, 29, 69-74.

Ceylan, E., &Geban, Ö. (2010). Facilitating Conceptual Change in Understanding State of Matterand Solubility Concepts by Using 5E Learning Cycle Model. *Hacettepe University Journal of Education,* 36, 41-50.

Chi. M.T.H, Slotta, J.D. and De Lecuno, N. (1994). From Things to Processes: *A Theory of ConceptualChange For Learning Science Concepts Learning & Instruction* 4, 47-45.

Chiu, M (2005).A National Survey of Students' Conceptionin Chemistry in Taiwan.*ChemicalEducation International,* 6, (1)

Chou, C. C. & Chiu, M. H. (2005).*A two-tier Multiple Choice Diagnostic Instrument on theMolecular Representations of Chemistry: Comparisons of Performance between Junior High and Senior High School Students in Taiwan*, Paper Presented at 18th International Conference on Chemical Education, August 3-8, Istanbul, Turkey.

Clement, J., Brown, D., &Zeitsman, A. (1989). Not all Preconceptions are Misconceptions:Finding 'Anchoring Conceptions' for Grounding Instruction on Students' Intuitions. *International Journal of Science Education,* 11, 554-565.

Cliff, W.H., (2009), Chemistry Misconceptions Associated with Understanding Calcium andPhosphate Homeostasis, *Advanced Physiological Education* 33, 323-328.

Dahiru, S.Y (2013) *Effect of using Gagne'sLearning Hierarchy on Chemistry Student's Academic Achievement and Anxiety Level in Balancing Chemical Equations in Secondary Schools in Katsina Metropolis, Nigeria.* An Unpublished Ph.D thesis Faculty of Education Ahmadu Bello University, Zaria.

Daluba,N.E.(2013) Effect of Demonstration Method of Teaching on Students' achievement in Agricultural Science.*World Journal of Education,*3(6),1-7

Davis, J.O. (2001). The Effect of Three Approaches to Science Instructions On Science Achievement. Dissertation Abstract Int. 39 (1) 211.

Demirci, N. (2001). The Effects of a Web-based Physics Software Program on Students'Achievement and Misconceptions in Force and Motion Concepts.PhD Dissertation. Florida Institute of Technology, Melbourne, Florida

Demirciogtu .G. (2009). Companion of The Effect On Conceptual Change Text Implementation After and Before Instruction On Secondary School Students' Understanding Of Acid-Base Concepts. *Asia Pacific Forum on Science Learning & Teaching.*10 Article Id:5.

Difficulties In Nuclear Chemistry Using Computer Animation Solutions: *Proceeded-Social And Behavioral Sciences,* 176 (2015), 103-104.

Disessa, A. A., &Sherin, B. L. (1998). What Changes in Conceptual Change? *InternationalJournal of Science Education,* 20, 1155-1191.

Driver, R. (1980).The Teaching and Understanding of Concepts in Science in N. Entwistle (ED). TheInternational Encyclopedia of Education .(2) England: Pergamon Press.

Duit, R.&Treagust, D. (2003). Conceptual Change: A Powerful Framework For Improving Science Teaching and Learning .*International Journal of Science Education.* 25(6) 671-688.

Duit, R. &Treagust, D.F. (2002).The teaching and learning of electrochemistry. In J. K. Gilbert, O. de Jong, R. Justi,D. F. Treagust. Chemical education: *towards research-basedPractice.*317-337.

Duit, R. &Treagust, D.F. (2008)."Students' Conceptions and Constructivist Teaching Approaches" in Improving Science Education.Edited by Barry J. Fraser & Herbert J. Walberg, 46-69. University of Chicago Press, Chicago.

Earl. J.O. (2000). Creative Thinking Development World of School Students (USA) [HYPERLINK "http//www.traintelligence.org/articles]

Echekwebu, H.O. (2009). Diagnosis of Learning Difficulties of the Senior Secondary School Students InElectrochemistry. An Unpublished M.Ed Thesis University of Nigeria, Nsukka, Nigeria.

Engelhardt, P. V., &Beichner, R. J. (2004).Students' Understanding of Direct Current Resistive Electrical Circuits.*American Journal of Physics,* 72, 98-115

Eniayegu, P.A. (2001). Seeking Meaning in Mole Ration Instruction. Journal On Secondary SchoolPhysics Learning. *Journal of Science Teachers Association*of Nigeria. 27(1) 147-155.

Eryılmaz, A. (2002). Effects of Conceptual Assignments and Conceptual Change Discussion on Students' Misconceptions and Achievement Regarding Force and Motion. *Journal of Research in Science Teaching*, 31(10), 1001-1015.

Ezenwa, V.I. (1993). A Comparative Study of the Effectiveness of Concept-Mapping and Guided Discovery Teaching On Secondary School Students' Understanding of Selected Chemistry Concepts. An Unpublished Ph.D Dissertation A.B.U., Zaria.

F.G.N (2013).Federal Ministry of Education. National Policy on Education.

Furst, E. J. (1958). *Constructing Evaluation Instruments*. New York: Longmas, Green Co.

Gabel, D. (2003). *Enhancing the Conceptual Understanding of Science Educational Horizon,*Winter70-76.

Garnett P.J. (2016), Chemistry Misconceptions at the Secondary Tertiary Interface Research GateArticle Retrieved.

Geban, O. (2012). Understanding the Acid-Base Concepts by Using Conceptual Change Approach. *Hacatte Universities Journal of Education,* 29, 69-70.

Geban, O. and Kaya .E. (2013).Effectiveness of Case-based Learning Instruction on Students' Understanding of Solubility Equilibrium Concepts. *H.U journal of education* 44, 97-108

Gilbert, J. K. (2006). On the Nature of "Context" in Chemical Education. *International Journal of Science Education,* 28 (9), 957– 976.

Gobinath, M. A. (2001). *Lectures on Conceptual Knowledge.* Saranda Ranganthan Endowment for Library Science Banalore, India.

Grasel, B.E. (2011). High Chemistry Students' and Prospective Chemistry Teacher's Misconceptions about Ionic Bonding.*Inonu University Journal of the Faculty of Education,* 12, 67-84.

Hassan, R. (2017). Effects of Conceptual Change Instructional Strategy on Students' Misconceptions and Academic Achievement in Practical Chemistry among Secondary School Students in Zaria. *Unpublished M.Ed Dissertation, Department of Science and Technology Education, Bayero University, Kano.*

Hamid, G. &Azita, O. (2009).Effects of Educational Factors on the Academic Performance of University Students in Chemistry. Bahonar University of Keman.

Harizal, Z.M. (2012). Analyzing of Students Misconceptions on acid-base Chemistry at SeniorHigh Schools in Medan, *Journal of Education and Practice.*3, 65-74.

Harrison, A. G. &Treagust, D. F. (2000). Learning about Atoms, Molecules, and Chemical Bonds: A Case Study of Multiple-model Use in Grade 11 Chemistry. *Science Education,* 84, 352–381.

Hewson, P. W.,&Gertzog, W. A. (1982). Accommodation of a Scientific Conception: Towards a Theory of Conceptual Change. *Science Education,* 66, 211-227.

Hewson, P.W. (1982). A Case Study of Conceptual Change in Special Relativity. The Influence of Prior Knowledge in Learning. *European Journal of Science Education* 4, 61-78.

Ikenne I.A. (2014). Remedying Students Misconceptions in Learning Of Chemical Bonding and Spontaneously Through Interaction, Discussion Learning Models (Idlm) *International Journal, Behavioral, Economic, and Instructional Engineering* 8 (10).

Ivowi, U.M.O (2010). Misconceptions in Science. foremost Educational Services Ltd, Lagos, Nigeria.

Ishaya, I.B. (2003). Strategies for Promoting Girls Interest in Science and Technology Education at the Junior Secondary School: The Role of the School. *International Journal of Children in Science and Technology*.

Jaakkola, T.&Nurmi, S. (2008). Fostering Elementary School Students' Understanding of Simple Electricity by Combining Simulation and Laboratory Activities. *Journal of Computer Assisted Learning.* 24, 271-283.

Jegede, S.A. (2010). Nigerian Students Perception of Technical Words in Senior Secondary School Chemistry Curriculum. *Pakistan Journal of Social Sciences* 7(2), 109-111.

Jodi, L.D. (2010) Development of Conceptual Understanding and Problem Solving Expertise in Chemistry. *Pakistan Journal of Education* 5(3), 205-220

Kaya .E. (2011), The Effects Of Conceptual Age Based Instruction On Students Understanding of Rate of Reaction Concepts Ph.D. Thesis Studies To Middle East Technical University.

Karpudewan, M., Roth, W.M. & Chandrakesan, K. (2015) Remediating Misconception on Climate Change among Secondary School Students in Malaysia. *Environmental Education Research,* 21 631-648

Kikas, E. (2004). Teacher's Conceptions and Misconceptions Concerning Three National Phenomena. *Journal of Research in Science Teaching,* 41 (5), 432 – 448

Kuhn, T. S. =970). *Structure of Scientific Revolutions*.2nd edition. Chicago: University of Chicago Press.

Lakpini, M. A. (2006) Effects of a Conceptual Change Instructional Strategy On The Achievement, Retention and Attitude of Secondary School Biology Students with Varied Ability. *Unpublished PhD Dissertation, Ahmadu Bello University, Zaria*.

Lawal, F.K. (2009). Effectiveness of Conceptual Change Instructional Strategy in Remediating Misconceptions in Genetics Concepts among Senior Secondary

School Students in Kano State. *Unpublished Ph.D Thesis.* Faculty of Education Ahmadu Bello University, Zaria.

Lawrence, A. and Abraham, C.O. (2011).Development of science process skill instruction. *Journal of Research in Science Teaching* 26,715-726

Lee, W.D. (2004) A Study on Causes of Elementary School Students' Misconceptions in Acid-base.Annual Report to the National Science Council in Taiwan (in Chinese).

Lilly, J.E, & Sirochman (2000).An Innovative College Curriculum Model for Teaching Science to Pre-Service Elementary Teachers. *Electronic Journal of Science Education,* December, 1-8.

Lovat, T. (2003).The Role of the 'Teacher' Coming of Age. Melbourne: Australian Council of Deans.

Mason, G. &Boscolo, T. (2000).Writing and Conceptual Change. What changes? Instructional Series. 28, 199-226

Mason, L. (2001) Introducing Talk and Writing for Conceptual Change: a Classroom study. *Learning and Instruction* 11, 305–329.

Mehrens, W.A & Lehman, I. J.(1984). *Measurement and Evaluation in Education.* New Jersey: *Educational Technology Publications.* 101-115.

Metin, M. (2011), Effects of Teaching Material Based 5E Model Removed Pre-service Teachers' Misconceptions about Acids-Bases, *Bulgerian Journal of Science and Education Policy,* 5(2), 274-302.

Modaic A.L. (2011). Students Misconceptions – Identifying and Reforming What They Bring In Chemistry Tabe, M.Sc Dissertation. Montana State University.

Muhammad, B.A. (2007). *Effects of Continuous Assessment on Academic Achievement of N.C.E. Chemistry Students In Kaduna State.* An Unpublished M.Ed Thesis. A.B.U. Zaria.

Muhammad, B.A.(2014) An Evaluation of the Efficacy of Conceptual Instructional method of Teaching Practical Chemistry :The case of secondary schools in Zaria Educational zone Kaduna State, Nigeria. *African Journal of Education and Technology*, 4(1), 112-118.

Mulhall, P., MC Kittrick, B., & Gunstone, R. (2001).A Perspective on the Resolution of Confusion in the Teaching of Electricity. *Research in Science Education,* 31, 575-587.

The National Research Council (NRC) (1997). Science Teaching Reconsidered: *A handbook*, Washington DC: National Academics press. http:// nap.edu/ sec.

Nbina, J.E. & Avwiri, E.(2014) Relative Effectiveness Of Context-Based Teaching Strategy on Senior Secondary Students Achievement in Inorganic Chemistry In Rivers State. AFRREV STECH,3(2),159-171.

Neidderer, H. (1987). A Teaching Strategy Based On Students' Alternative Conceptions and Examples. In: Proceedings of the Second International Seminar. Misconceptions and Educational Strategies in Science and Mathematics. 2:360-367. Cornell University Press.

Njoku, Z.&Eze Odurunkwe, P.I. (2014). Resolving Nigerian Secondary School Students Learning

Njoku, Z.C. (2005). Levels of Chemistry Practical Skills Acquired By Senior Secondary School (SSII) Students. Nigerian *Journal of Professional Teachers* 2(1), 88.

Obeka, S. S. (2009). Resources for Teachers in Effective Management of Learning in Large Classes: *A paper presented at the workshop on resource mobilization, management for access and quality education.* Faculty of Education, ABU Zaria

Okebukola, P.A. (2002). *Beyond The Stereotype to New Trajectories in Science Teaching.* Published By Science Teachers Association Of Nigeria, STAN.

Olorukooba. S. B. (2001). *The Relative Effects of Cooperative Instructional Strategy and Traditional Method on the Performance of Senior Secondary School Chemistry Students.* Unpublished Ph.D Dissertation Ahmadu Bello University, Zaria.

Oloyede, O. I. (2010). Enhanced Mastery Learning Strategy on the Achievement and Self Concept in Senior Secondary School Chemistry. *Humanity and Social Sciences Journal,* 5(1), 19-24.

Omwirhiren, E.M. & Ubanwa, A. O. (2016). An Analysis Of Misconceptions In Organic Chemistry Among Selected Senior Secondary School Students In Zaria Local Government Area Of Kaduna State, Nigeria. *International Journal of Education and Research.* 247-266.

Omwirhiren, E.M (2013) An Investigation into the Relative Effectiveness of Laboratory and Lecture Instructional Strategy on Students' Achievement and Retention in some Selected Topics in SSCE Chemistry. Sardauna *Journal of Multi-disciplinary Studies.* 3(1), 207-213.

Onder, I. &Geban, O. (2006).Three Effects of Conceptual Change Text on Students Understanding of the Solubility-Equilibrium Concept. *Journal of Education* 30, 165-173.

Onwu, G. O. (2002).*Learning difficulties in science.* Capacity Limitation or Processing Deficit Published Inaugurate Lecture University of Venda for Science and Technology 1-38.

Opara, F. &Waswa, P.(2013) Enhancing Students' Achievement in Chemistry Through the Piagetian Model: The learning Cycle. *International Journal for Cross-Disciplinary Subjects in Education (IJCDSE),* 4(4), 1270- 1278.

Orgill, M.& Sutherland .A. (2008). Undergraduate Chemistry Students' Perception of Misconceptions about Buffers and Buffer Problems Chemistry Education :*Research and Practice,* 9,131-143.

Osborne .R. & Cosgrove M. (1985). Chemistry and Learning In Science Project Chemistry In New Zealand, 10. 104-106.

Osborne. R.J. &Wittrock, M.C. (1983). Learning Science: A Generative Process. Science Education 67, 489-508.

Osterlund, L.L. & Ekborg, M. (2009). Students Understanding of Acid-Base Concept in Three Situations.*NORDINA* 5 (2), 115-127.

Otuka, J.O.E (1991). The Laboratory Think and Do Approach to Science Instruction. *Journal of Science Teachers Association of Nigeria, 27(1), 163-167.*

Oversby, J. (2000). Models in Explanations of Chemistry: The case of Acidity. In J. K. Gilbert &C. J. Boulter (Eds.), Developing Models in Science Education. Dordrecht/Boston/London: Kluwer Academic.

Ozmen. H; Gokhan, D; Burhan,Y; Naseriazar, A &Hulya, D (2012). Using Laboratory Activities Enhanced with Concept Cartoon to Support Progression in Students' Understanding of Acid-base Concepts.*Asia pacific forum on Science Learning and Teaching.*13, issue1, article 8, (1).

Pabuccu, A. &Geban, O. (2006). Remediation Misconceptions Concerning Chemical Bonding Through Conceptual Change text. *Hacettepe University Journal of Education,* 30, 184-192.

Palmer, D.H (2001). Investigating the Relationship between Reputational Text and Conceptual Change.*Science Education,* 87: 663-684.

Pekmez S. E. (2010). Using analogies to prevent misconceptions about chemical equilibrium.*Asia-Pacific Forum on Science Learning and Teaching,* 11(2), 1-35.

Piaget, J. (1977). *The Development of Thought.*Translated By A. Rosin, Oxford: Blackwell.

Posner, G.J; Strike, K.A; Hewson, P.W. and Gertzog, W.A.(1982). Accommodation of a Scientific Conception Towards a Theory of Conceptual Change. *Science Education,* 66, 211-227.

Rollnick, M. & Rutherford, M. (2011).“The Use of a Conceptual Change Model and Mixed Language Strategy for Remediating Misconceptions on Air Pressure” *International Journal of Science Education* 15, 4.

Roth, K. J. (1985). Conceptual Change Learning and Student Processing of Science texts. Paper presented at the annual meeting of American Research Association, Chicago, 46.

Sadera, W.A.(2006). Conceptual Change-Based Instruction and Pre-service Teacher Technology Preparation: *A Collective Case Study Retrospective Thesis and Dissertation Lower State University*

Sambo, A. A. (2008). Research Strategies in Education, stirling- horden publishers (Nig.) ltd. University Post Office Oyo state, Nigeria

Sarikaya, M (2007). Prospective Teachers' Misconceptions about the Atomic Structure in the Context of Electrification by Friction and an Activity in order to Remedy Them,*International Education Journal,* 8, 40-63.

Sendur .C. &Tropak .M. (2013). The Role Of Conceptual Change Text To Improve Students' Understanding of Alkenes Chemistry Education Research And Practical 14, 431-449.

Sherma, K.K. &Sherma L.K. (2004).Physical Chemistry for B.ScHons.Students of India Universities.Revised Edition.

Strike, K. A. & Posner, G. J. (1985).A Conceptual Change view of Learning and Understanding.In L. West & L. Pines (Eds). Cognitive Structure and Conceptual change 259-266. Orlando. FL.: Academic Press.

Sugur, S. Tekkey, C. &Geban.O. (2006). Improving Through Problem Based Learning. EducationalResearch, 40(4), 155-160.

Suleiman, H.A. (2007). Nigerian Education in Global Perspective, Emerging Roles of Informal and Communication Technology ICT in Science Education.*Paper Presented At the School of Education, Federal College Of Education, Katsina*.

Taber, K.S. (2011). An Alternative Conceptual Framework from Chemistry Education.*International Journal of Sciences Education*, 20(5), 597-608.

Tastan, I., Dikmenli, M. & Cardak (2008). Effectiveness of the Conceptual Change Text Accompanied by Concept Maps about Students' Understanding of the Molecules Carrying Genetical Information. *Asia-pacific forum of learning and teaching.*9(1)11(1).

Tamer, G.A & Carol, S. (2014). Students Conceptions and Conceptual Change: Their Overlapping Phases of Research. Handbook of Research in Science Education 2 New York

Tamir, P., Arzi, R., & Ziva, D. (2014). Attitudes of Israeli high school students towardsphysics.*Science Education,* 58(1), 75-86.

Taşlıdere, E (2013). Effect of Conceptual Change Oriented Instruction on Students' Conceptual Understanding and Decreasing Their Misconceptions in DC Electric Circuits.*Creative Education.*4(4), 273-282

Teichert, M. & Stacy, A. (2003), Promoting Understanding of Chemical Bonding andSpontaneity Through Student Explanation and Integration of Ideas. *Journal of Research in Science Teaching,* 39, 464-496.

Tracy, M. B. (2006). *Defining the importance of employability skills in career/technical Education unpublished PhD dissertation faculty of Auburn university*

Treagust, D.F. (2010).States of Matter, Changes of State and Diffusion : A Cross National Study, *International Journal of Science and Mathematics Education,* 8, 141-164.

Udoh, O.A. (2008). An Analysis of Classroom Interaction of Senior Secondary School Chemistry Teachers in Ikot Ekpene Local Government Area of AkwaIbom State Nigeria. *Journal of the Science Teachers Association of Nigeria,* 43(1 & 2), 16-22.

UNESCO (2005).Group Techniques in Educational Science Teaching Schools of Tropical Africa.

Usman, I.A. (2006).Strategies for Conducting Practical in Science, Technology and Mathematics.A Lead Paper Presented at STAN Workshop at Federal Government Girls College Malali, Kaduna.

Vosniadou, S. (2007).Conceptual Change and Education.*Human Development*, 50, 47-54.

West African Examination Council (WAEC) Annual Report, 2010- 2014

Wikipedia, (2009).Free Encyclopedia Wikipedia Available online at http//Wikipedia.org/Wiki/acid

Wood, R. (1990). Item analysis; in walbeng, H. J. and Hearter G. O. (eds). the international Encyclopedia of Education Evaluation Oxford.

YezierskiO. &Birk, J.P. (2006) , Misconceptions about the Particulate Nature of Matter. Using Animations to Close the Gender Gap, *Journal of Chemical Education,* 83, 954.

**Appendix I**

**Acids and Bases Misconception Test (ABMT)**

Instructions: Answer all questions. Write as precisely as possible with the space provided. Candidates are at liberty to write their names or not.

Time allowed: 1hour

Name:

School:

Gender:

1. Describe what an acid is ______________________________________________

______________________________________________________________

2. List two examples of acids ____________________________________________

______________________________________________________________

3. State the natural sources of acids _______________________________________

______________________________________________________________

4. State the classification of acid ________________________________________

______________________________________________________________

5. List three properties of acids __________________________________________

______________________________________________________________

6. Describe what a base is _______________________________________________

______________________________________________________________

7. List two examples of bases ____________________________________________

______________________________________________________________

8. State the natural sources of bases? ______________________________________

______________________________________________________________

9. State the classification of base _________________________________________

______________________________________________________________

10. List three properties of bases _________________________________________

______________________________________________________________

11. State what can be used in the laboratory to test acidic and basic substance

______________________________________________________________

______________________________________________________________

12. Define the term pH_____________________________________________________

_____________________________________________________________________

13. How does pH measure the concentration of acids? __________________________

_____________________________________________________________________

14. How does pH measure the concentration of bases _____________________________

_____________________________________________________________________

15. How does acids and bases reacts with each other

_____________________________________________________________________

_____________________________________________________________________

16. What is a strong base? _________________________________________________

_____________________________________________________________________

_____________________________________________________________________

17. What is a weak base? ___________________________________________________

_____________________________________________________________________

18. Describe the concept of POH _____________________________________________

_____________________________________________________________________

19. What could be used to measure acidity and alkalinity of a solution ______________

_____________________________________________________________________

20. Describe what buffer solution means. ______________________________________

_____________________________________________________________________

## Appendix II

## Acids BasesPerformance Test (ABPT)

Instructions:

Attempt all questions. Each question is followed by five options. Circle the correct answer.
Name of school:
Class:
Gender:
Age:

1. An acid is a substance which in the presence of water produces:
    a. Salts
    b. Oxygen
    c. Effervescence
    d. Hydrogen gas
    e. Hydroxonium ions
2. Which of the following is a general method of preparing acids
    a. Direct combination of constituent elements.
    b. Double decomposition involving salt solution.
    c. Reaction between an hydride and water.
    d. Reaction between a base and an amphoteric acid.
    e. Dissolution of hydroxides followed by neutralization.
3. Tetraoxosulphate (vi) acid is described as a strong acid because it is highly:
    a. Oxidizing
    b. Concentrated
    c. Reactive
    d. Ionized completely in water
    e. Neutral
4. Which of the following acid is not monobasic?
    a. Hydroflouric acid
    b. Hydrochloric acid
    c. Trioxonitrate (v) acid
    d. Ethanoic acid
    e. Tetraoxosulphate (vi) acid

5. Consider the following acid-base equilibrium

$HCO^{3-} + H_2O \rightleftharpoons H_2CO_3 + OH^-$

In the reaction above,Bronsted-lowry acids are

a. $H_2O$ and $OH^-$

b. $HCO^{3-}$ and $OH^-$

c. $H_2O$ and $H_2CO^{3-}$

d. $HCO^{3-}$ and $H_2CO^3$

e. $H^+$ and $OH^-$

6. All alkalis changes litmus paper from:

a. Orange to red

b. Red to blue

c. Blue to green

d. Blue to red

e. Purple to orange

7. When an acid reacts with an alkali to form salt and water only, the reaction is termed:

a. Hydration

b. Neutralization

c. Direct combination

d. Hydrolysis

e. Esterification

8. Why are indicators used in acid-base titration?

a. So as to determine the exact volume of acid needed to neutralize a given volume of base and vice-versa

b. So as to determine the pH of both the acid and the base

c. Because an acid requires an indicator before it can react with a base

d. Because indicator are acids which first have to be neutralized by the base

e. All of the above

9. The characteristics of properties of an acid is due to the presence of:

a. Hydride ion

b. Hydroxyl ion

c. Hydroxonium ion

d. Oxide ion

e. Chloride ion

10. The pH of a carbonated drink is

a. Less than 7
b. More than 7
c. Equal to 7
d. Approximately 7.8
e. Exactly 10

11. The pH of four solution W.X.Y.Z are 4,6,8,10 respectively, therefore

a. None of these solution is acidic
b. The pH of Y can be made acidic by adding water
c. Z is the most acidic
d. W is acidic
e. X is neutral

12. Which of the following elements form more than one acidic oxide?

a. Hydrogen
b. Sulphur
c. Aluminum
d. Iron
e. Carbon

13. The brownish-yellow color of concentrated trioxonitrate (v) acid is due to the presence of:

a. Nitrogen
b. Iron (iii) salt
c. Excess air
d. Nitrogen (iv) oxide
e. Nitrogen (ii) oxide

14. A chemical indicator has a transition point at POH = 8.0. calculate its Ka value and identify the indicator

a. Ka = $1\times10^{-8}$ phenol red
b. Ka = $1\times10^{-6}$ methyl red
c. Ka = $1\times10^{-8}$hymol blue
d. Ka = $1\times10^{-6}$chlorophenol red
e. Ka = $1\times10^{-3}$phenolphthalene purple

15. Substances which produce hydroxonium ions as the only positive ion when dissolved in water:

a. React with water to form acids
b. React with water to form alkali
c. Show both acidic and basic properties
d. React with acids and alkali
e. Contain high proposition of oxygen

16. Which of the following is a characteristic property of weak acid in solution?

a. It contain mostly molecules
b. It contain mostly ions
c. It turns blue litmus red
d. It contains both molecules and ions
e. It contain less water

17. The number of replaceable hydrogen atoms in one molecule of an acid indicates its:

a. Basicity
b. Acidity
c. Alkalinity
d. Reactivity
e. pH value

18. Which of the following is not an organic acid?

a. Lactic acid
b. Citric acid
c. Fatty acid
d. Hydrochloric acid
e. Amino acid

19. What is the value of pKw at 25$^{o}$C

a. $1.0 \times 10^{-14}$
b. $1.0 \times 10^{-7}$
c. $1.0 \times 10^{-12}$
d. 7.00
e. 14.00

20. Find the hydrogen and hydroxide ion concentration in 0.01M tetraoxosulphate (vi) acid solution.

a. $0.5\times10^{-12}$

b. $0.3\times10^{-12}$

c. $1.3\times10^{-12}$

d. $0.3\times10^{-11}$

e. $0.3\times10^{-10}$

21. The number of species in one mole of a substance is the:

a. Concentration

b. Atomicity

c. Oxidation

d. Quantum number

e. Avogadro number

22. Find the PH in which the hydrogen ion, $H^+$ concentration is $6.38\times10^{-6}$

a. 5.2

b. 1.0

c. 3.4

d. 4.4

e. 1.4

23. A solution of pH 7 is:

a. Acidic

b. Neutral

c. Concentration

d. Dilute

e. Saturated

24. Which of the following equations represents a neutralization reaction?

a. $CaOCl_2 + 2HCl \longrightarrow Cl_2 + CaCl_2 + H_2O$

b. $Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

c. $H_2SO_4 + KOH \longrightarrow KHSO_4 + H_2O$

d. $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

e. $CuSO2 + 2NaOH \longrightarrow Cu(OH)_2 + Na_2SO_4$

25. A buffer solution can be formed by dissolving equal moles of

a. HF and NaF

b. HCl and NaOH

c. KBr and $NaPO_4$

d. $CH_3COOH$ and NaCl

e. $H^+$ and $OH^-$

26. An aqueous sodium trioxocarbonate (iv) solution is alkaline because the salt is:

a. Hydrolyzed

b. Formed from strong base

c. Fully ionized in water

d. Strong electrolyte

e. Not decomposed by heat

27. Addition of HCl to water causes

a. Both $H_3O^+$ and $OH^-$ to increase

b. Both $H_3O^+$ and $OH^-$ to decrease

c. $H_3O^+$toincrease and $OH^-$ to decrease

d. $H_3O^+$ decrease and $OH^-$ to increase

e. None of the above

28. In a solution of 0.01M NaCN, the ion concentration from highest to lowest is

a. $[Na^+] > [OH^-] > [CN^-] > [H_3O^+]$

b. $[Na^+] > [CN^-] > [OH^-] > [H_3O^+]$

c. $[H_3O^+] > [OH^-] > [CN^-] > [Na^+]$

d. $[Na^+] > [OH^-] > [CN^-] > [H_3O^+]$

e. $[OH^-] > [Na^+] > [CN^-] > [H_3O^+]$

29. Which among the following bases is soluble in water?

a. $Fe(OH)_3$

b. $Cu(OH)_2$

c. $Zn(OH)_2$

d. NaOH

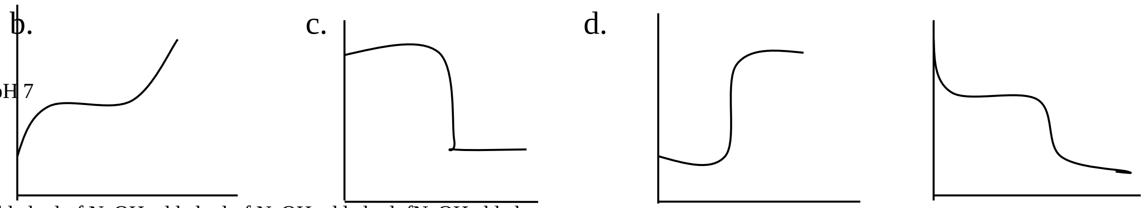
e. $Ca(OH)_2$

30. All are acids except
   a. HCl
   b. $H_2SO_4$
   c. NaOH
   d. $HNO_3$
   e. $CH_3COOH$

31. Which of the titration curves represents the titration of HCl and NaOH?

a. b. c. d.

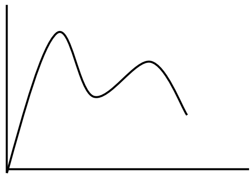
pH 7pH 7pH 7pH 7



vol of NaOH addedvol of NaOH addedvol of NaOH addedvolofNaOHadded

e.

pH7

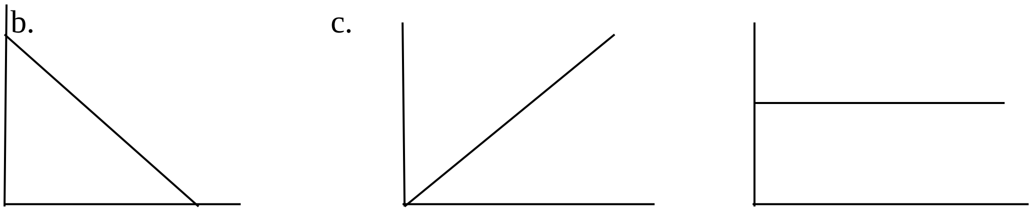


vol of NaOH added

32. Which of the following graphs describe the relationship between pH and POH

a. b. c.

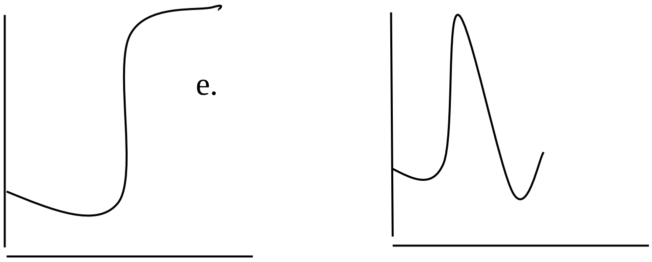
pHpHpH



pOHpOHpOH

d. e.

pHpH



pOHpOH

33. Which of the following acid is largely present in sour milk?
   a. Tartaric acid
   b. Lactic acid
   c. Citric acid
   d. Methanoic acid
   e. Ethanoic acid

34. The basicity of ethanoic acid is:

a. 1 b. 2 c. 3 d. 4 e. 5

35. Which of the following species is always present in acidified water?

a. $NH_4^+$ b. $O^{2-}$ c. $H_3O^+$ d. $HNO_3$ e. $H_2O$

36. The expression Y = -Log $[H^+]$ defines:

a. Ka b. Pk c. DG d. pH e. DH

37. What mass of tetraoxosulphate (vi) acid is contained in $400cm^3$ of 0.50cm solution?

a. 0.5mg b. 9.8g c. 14.7g d. 19.6g e. 49.0g

(H= 1.0, O= 16, S= 32.1)

38. A buffer solution may contain equal moles of:

a. Weak acid and strong base
b. Strong acid and strong base
c. Weak acids and its conjugate base
d. Strong acid and its conjugate base
e. Weak acid and weak base

39. which are the correct products for the these reactants

HCl + NaOH →

a. HOH + ClNa
b. NaCl + H2O
c. $H_3O$ + $NaCl_2$
d. NaOH + Cl
e. NaOH + NaCl

40. What is the molarity of HCl solution if 50.0ml is neutralized in a titration by 40.0ml of 0.406M NaOH?

a. 0.200m
b. 0.280m
c. 0.320m
d. 0.500m
e. 0.100m

# Appendix III

## Marking scheme for ABPT

1. E
2. C
3. D
4. E
5. C
6. B
7. B
8. A
9. C
10. A
11. D
12. B
13. D
14. C
15. A
16. C
17. A
18. D
19. E
20. A
21. D
22. A
23. B
24. B
25. A
26. C
27. C
28. B
29. D
30. D
31. C
32. A
33. B
34. A
35. C
36. D
37. B
38. C
39. B
40. A

## Appendix IV
## Right answers, Facility (FI) and Discrimination (D) Indices for Acid and Base concept Performance Test (ABPT)

| SN | Right answers | Right scores | $R_U$ | $R_L$ | Facility Index F.I = $\frac{R}{T}\times100$ | Item Discrimination D.I = $\frac{R_U - R_L}{^1/_2N}$ |
|---|---|---|---|---|---|---|
| 1 | Hydroxonium ions | 20 | 7 | 1 | 0.66 | 0.40 |
| 2 | Reaction between an hydride and water | 17 | 9 | 2 | 0.56 | 0.46 |
| 3 | Ionized completely in water | 15 | 8 | 2 | 0.50 | 0.40 |
| 4 | Tetraoxosulphate (vi) acid | 19 | 8 | 2 | 0.63 | 0.40 |
| 5 | $H_2O$ and $H_2CO^{3-}$ | 15 | 9 | 3 | 0.50 | 0.40 |
| 6 | Red to blue | 25 | 10 | 3 | 0.83 | 0.46 |
| 7 | Neutralization | 20 | 9 | 5 | 0.66 | |
| 8 | So as to determine the exact volume of acid needed to neutralize a given volume of base and vice-versa | 12 | 7 | 2 | 0.40 | 0.33 |
| 9 | Hydroxonium ion | 23 | 9 | 2 | 0.76 | 0.46 |
| 10 | Less than 7 | 20 | 9 | 4 | 0.66 | 0.33 |
| 11 | W is acidic | 19 | 8 | 3 | 0.63 | 0.33 |
| 12 | Sulphur | 19 | 7 | 2 | 0.63 | 0.33 |
| 13 | Nitrogen (iv) oxide | 22 | 8 | 3 | 0.73 | 0.33 |
| 14 | Ka = $1\times10^{-8}$hymol blue | 25 | 8 | 0 | 0.83 | 0.53 |
| 15 | React with water to form acid | 19 | 7 | 3 | 0.63 | 0.33 |
| 16 | It turns blue litmus red | 23 | 10 | 3 | 0.76 | 0.46 |
| 17 | Basicity | 25 | 9 | 1 | 0.83 | 0.53 |
| 18 | Hydrochloric acid | 19 | 8 | 2 | 0.63 | 0.40 |
| 19 | 14.00 | 20 | 8 | 2 | 0.66 | 0.40 |
| 20 | $0.5\times10^{-12}$ | 15 | 7 | 2 | 0.50 | 0.33 |
| 21 | Quantum number | 17 | 8 | 1 | 0.56 | 0.46 |
| 22 | 5.2 | 16 | 7 | 2 | 0.53 | 0.33 |
| 23 | Neutral | 23 | 9 | 3 | 0.76 | 0.40 |
| 24 | $Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$ | 18 | 8 | 2 | 0.60 | 0.40 |
| 25 | HF and NaF | 20 | 8 | 2 | 0.66 | 0.40 |
| 26 | Fully ionized in | 24 | 9 | 3 | 0.80 | 0.40 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | water | | | | | |
| 27 | $H_3O^+$ toincrease and $OH^-$ to decrease | 18 | 8 | 2 | 0.60 | 0.40 |
| 28 | $[Na^+] > [CN^-] > [OH^-] > [H_3O^+]$ | 15 | 7 | 1 | 0.50 | 0.40 |
| 29 | NaOH | 23 | 10 | 3 | 0.76 | 0.70 |
| 30 | $HNO_3$ | 19 | 9 | 2 | 0.63 | 0.70 |
| 31 | C | 17 | 9 | 1 | 0.56 | 0.53 |
| 32 | A | 14 | 8 | 3 | 0.46 | 0.33 |
| 33 | Lactic acid | 21 | 10 | 2 | 0.70 | 0.53 |
| 34 | 1 | 21 | 8 | 3 | 0.70 | 0.33 |
| 35 | $H_3O^+$ | 21 | 9 | 2 | 0.70 | 0.46 |
| 36 | Ph | 13 | 10 | 3 | 0.43 | 0.46 |
| 37 | 9.8g | 15 | 7 | 1 | 0.50 | 0.40 |
| 38 | Weak acids and its conjugate base | 16 | 7 | 2 | 0.53 | 0.33 |
| 39 | NaCl + H2O | 26 | 8 | 2 | 0.86 | 0.40 |
| 40 | 0.200m | 11 | 9 | 0 | 0.36 | 0.60 |

## Appendix V

## Lesson Plans for Experimental Group

## LESSON PLAN ONE

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topic:** **Definition, classification and basicity of acids**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Instructional materials:** Lemon Juice, Orange juice, Litmus paper, beaker some sample of carbonated cola, vinegar

**Behavioral objectives:** by the end of the lesson the students should be able to:

1. Define acids
2. State the classes of acids
3. Describe how an acid behaves in solution.
4. Define the term basicity of an acid
5. State the basicity of some common acid

**Presentation**

**Step 1: Orientation and Awareness Phase**

**Teacher Activities:** Teacher introduces the topic and asks the following question:

a. What is an acid
b. State the classes of acid
c. Describe acids in solution
d. Describe what a strong and weak acid is.
e. Define the term basicity of an acid
f. Indicate the basicity of some common acids

**Student activities:** Students discuss and sought answers to the questions raised **(7MINUTES)**

**Step 2: Elicitation of Idea or Disequilibrium Phase**

**Teacher activities:** Teacher guides the student and moderates student ideas.

**Student activities:** Student form small group maximum of 5 at least 3 student observe the conclusion of such discussion will be writing out on the poster by their team leader. The captain of the poster will be our ideas about "acid".**(8MINUTES)**

**Step3: Reformation Phase**

**Teacher Activities:** Teacher continues to act as a facilitator. He provides learning experience and questions that on discussion, leads to interaction with students' prior knowledge through:

i. Extending students prior knowledge where the ideas are limited.

ii. Helping students to refine their own ideas to scientifically validated ideas.

iii. The teacher at this stale will then re-emphasize on scientifically correct ideas

**Student Activities:** Reports from each of the groups will be posted by team leaders on the chalk board containing the student ideas.

i. As students explain their ideas, alternative viewpoints are identified.

ii. Students will then be helped to recognize and critically examine such.**(11MINUTES) REMEDIATION PHASE**

**Step4: Application Phase**

**Teacher activities:** The students' are ask question on how the knowledge of acids can help them state classes of acids and describe acids in a solution.

**Student activities**: students to discuss the answers to the questions on their small groups and arrive at concrete suggestion.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** The teacher asks the students the following questions.

a. What is an acid

b. State the classes of acid

c. Describe acids in solution

d. Describe what a strong and weak acid is.

e. Define the term basicity of an acid

f. Indicate the basicity of some common acid

**Student activities:** The students will respond to the questions with explanation in each case.**(7MINUTES)**

## LESSON PLAN TWO

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topic:** **Properties of acids**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Instructional materials:**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

1. State the physical properties of acids
2. Explain the chemical properties of acids

**Presentation**

**Step1: Orientation and Awareness Phase**

**Teacher activities:** The teacher introduces the topic by asking student in their various groups to observe again an acid and list physical properties of acid.

The students are also asked to state the chemical properties of acids.

**Student activities:** The students in their groups describe the physical properties of an acid. The students discusses among themselves about what they think physical and chemical properties of acid would be.**(7MINUTES)**

**Step 2: Elicitation of Idea or Disequilibrium Phase**

**Teacher activities:** Teacher act as a facilitator or guide to the students.

**Student activities:** The summaries of students' discussions are written out on the chalkboard and tagged "student ideas about the physical and chemical properties of acid.

These are displayed on the chalkboard, while the teams leader of the group explain the finding of the group to the class other aspect that can be listed by the aid of practical are also discussed.**(8MINUTES)**

**Step3: Reformative Phase**

**Teacher activities:** The teacher asks question based on the discussion leads to interactions with students' prior knowledge through:

i. Extending prior knowledge where ideas are limited

ii. Ask student to refine their ideas to scientifically validated ideas and re-emphasize scientifically valid ideas.

**Student activities:** as the idea of each team is being explained by the groups, alternative viewpoints are identified and students are thus helped to recognize and critically examine such alternatives viewpoints.**(11MINUTES) REMEDIATION PHASE**

**Step4: Application Phase**

**Teacher activities:** Teacher asks questions on how the knowledge of acid can help to explain the physical and chemical properties of acid.

**Student activities:** Student discusses the answers to the question in their respective group and arrives at concrete suggestion on the physical and chemical properties of acids.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** Teacher asks the following question:

i. List the physical properties of acid

ii. Give 3 chemical properties of acids

**Student activities:** The students give response to the questions raised by the teacher giving explanation in each case.**(7MINUTES)**

## LESSON PLAN THREE

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topic:** **Preparation of acid and uses**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Instructional materials: dil HCl, milk,**

**Behavioral objectives:** by the end of the lesson the students should be able to:

1. Outline the general methods for preparation of acids
2. List some of the uses of acids

**Presentation**

**Step 1: Orientation and Awareness Phase**

**Teacher Activities:** The teacher introduces the topic by asking the following questions:

i. What are the general methods used for preparation of acids

ii. What are the possible uses of acids?

**Student activities:** students discusses of answer to the questions the teacher raised by various group. The final answers are written on the cardboard sheet in each group. These are tagged "student ideas as on method of preparation and uses if acids"**(7MINUTES)**

**Step 2: Elicitation of Ideas or Disequilibrium Phase**

**Teacher activities:** The teacher acts as facilitator guides and moderates students ideas.

**Student activities:** In their working group, students describe and illustrate how preparation is made. While presenting the various methods and uses students discuss within themselves and the conclusion of discussion to presented and captioned "students' ideas about methods of preparation and uses of acids. **(8MINUTES)**

**Step 3: Reformative Phase**

**Teacher activities:** The teacher continues to acts as a facilitator and moderator of student ideas.

The teacher asks question that on discussion leads to interactions with the student prior knowledge through:

i. Extending prior knowledge where ideas are limited

ii. Helping students to refine their own ideas to scientifically validated ideas.

iii. At this stage the teacher re-emphasize scientifically correct ideas.

iv. These are now written out on the chalkboard beside the student ideas.

**Student activities:** Report from each of the group is displayed by the team leader on the chalkboard.

Each team leader gives full explanation of the ideas of the group. As these explanations are identified, the students are then helped to recognized, critique and examine such alternative points. **(11MINUTES) REMEDIATION PHASE**

**Step 4: Application Phase**

**Teacher activities:** Teacher asks questions on how the knowledge of acid can help students to explain:

a. The method of preparation of acids.

b. Uses of acids.

**Student activities:** Students discuss the answer to questions in their small group and arrives at concrete suggestion on how acids can be prepared and their uses.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** The teacher then asks the following questions:

a. What are the methods of preparation of acids? Illustration with equation

b. What are the uses of acids?

**Student activities:** Students then gives responses to the questions raised by the teacher giving explanation in each case. Answers will now be scientifically accepted ideas.

**(7MINUTES)**

## LESSON PLAN FOUR

**Subject:** **Chemistry**

**Topic:** **Bases**

**Sub-topic:** **Definition, classes and neutralization**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Teaching materials:** **NaOH, cleaning glass, litmus paper**

**Behavioral objectives:** by the end of the lesson the students should be able to:

1. Define the concept base
2. State the classes of base
3. Define neutralization

**Presentation**

**Step 1: Orientation and Awareness Phase**

**Teacher Activities:** The teacher introduces the topic by asking questions to inquire into the student cognitive structure to determine their previous ideas about the topic:

a. What is a base?

b. State the classes of base.

c. What is neutralization?

**Student activities:** The students discuss answers to the question raised by the teacher in their various group.The answers to the questions are written on a cardboard sheet tagged "student ideas about bases".**(7MINUTES)**

**Step 2: Elicitation of ideas or Disequilibrium Phase**

**Teacher activities:** The teacher continues to act as a facilitator and a guide

**Student activities:** In each of working group students observe and make representation of what they observe. The leader also discusses the views of group on the concept of bases neutralization and classes of base. **(8MINUTES)**

**Step 3: Reformative Phase**

**Teacher activities:** At this phase the teacher discuss with the students the identified alternative view point.

The teacher acts as a guide and facilitator providing guiding question that lead to students to the formulation of scientifically accepted responses.

i. Correct responses given by the student were re-emphasize by the teacher

ii. As the discussion go on misconceived ideas are written on the card board are being thrashed one after the other.

iii. The teacher finally gives summary of the ideas arrived at and place emphasis on those that constitute a common source of misconception

**Student activities:** The student takes part in the discussion and are made to understand their alternative view. The team leaders are further made to give scientifically valid ideas about bases, neutralization and classes of base.**(11MINUTES) REMEDIATION PHASE**

**Step 4: Application Phase**

**Teacher activities:** The teacher leads the students to summarize the concept of bases, its classes, and the word neutralization as well.

**Student activities:** The students discuss the points in order to understand the scientifically valid ideas better.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** As a facilitator, the teacher asks the following guiding and leading questions:

i. What is a base?

ii. State the classes of base.

iii. What can be described as neutralization?

**Student activities:** Students discuss the questions and together are convinced. Answers will now be scientifically valid ideas. **(7MINUTES)**

**LESSON PLAN FIVE**

**Subject:** **Chemistry**

**Topic:** **Bases**

**Sub-topic:** **Preparation of bases**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Instructional material:**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

1. List the physical properties of bases
2. List the chemical properties of bases
3. Mention some of the uses of bases

**Presentation**

**Step 1: Orientation and Awareness Phase**

**Teacher Activities:** The teacher introduce the topic by introducing the topic by asking student in their various group to observe again a base using litmus paper and list physical properties of acid. The students are also asked to state the chemical properties of base.

**Student activities:** The students in their groups observe and describe the physical base properties of a base. The students discusses among themselves about what they think physical and chemical properties of base would be.**(7MINUTES)**

**Step 2: Elicitation of Idea or Disequilibrium Phase**

**Teacher activities:** Teacher act as a facilitator or guide to the student

**Student activities:** The summaries of students' discussion are written out on the chalkboard and tagged "student ideas about the physical and chemical properties of base. These are displayed on the chalkboard, while the teams leader of the group explain the finding of the group to the class other aspect that can be listed by the aid of practical are also discussed.**(8MINUTES)**

**Step 3: Reformative Phase**

**Teacher activities:** The teacher asks questions based on the discussion leading to interactions with students' prior knowledge through:

iii. Extending prior knowledge where ideas are limited

iv. Ask student to refine their ideas to scientifically violated ideas and re-emphasize scientifically valid ideas.

**Student activities:** as the ideas of each team are being explained by the group, alternative viewpoints are identified and students are thus helped to recognize and critically examine such alternatives viewpoints.**(11MINUTES) REMEDIATION PHASE**

**Step 4: Application Phase**

**Teacher activities:** Teacher asks questions on how the knowledge of base can help to explain the physical and chemical properties of base.

**Student's activities:** Student discusses the answer the question on their respective group and arrives at concrete suggestion on the physical and chemical properties of base.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** Teacher asks the following question:

iii. List the physical properties of base

iv. Give 3 chemical properties of base

**Student activities:** The students give responses to the question raised by the teacher giving explanation in each case.**(7MINUTES)**

## LESSON PLAN SIX

**Subject:** **Chemistry**

**Topic:** **Acids and Bases**

**Sub-topic:** **Measurement of acidity and alkalinity**

**Duration:** **40minutes**

**Class:** **SS1**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Teaching Method:** **Conceptual Change Instructional Strategy**

**Instructional material: Indicators, pH scale**

**Behavioral objectives:** by the end of the lesson the students should be able to:

1. State what could be used to Measure the acidity and alkalinity of a solution
2. Define pH and state its importance
3. Describe the term indicator
4. Define an acid-base indicator
5. State an acid-base titration
6. Define a buffer solution

**Presentation**

**Step 1: Orientation and Awareness Phase**

**Teacher activities:** Teacher introduces the topic by asking the students in their various groups to state what could be used for the measurement of acidity and alkalinity of a solution.

**Student activities:** Students in their various groups observe the pH scale, indicators and solution given to them and discusses about the changes that occurred in their litmus papers and solution. The final answers are written on the cardboard sheet in each group. These are tagged "student ideas as on what could be used for the measurement of acidity and alkalinity of a solution. **(7MINUTES)**

**Step 2: Elicitation of Idea or Disequilibrium Phase**

**Teacher activities:** The teacher acts as a guide and facilitator to the students

**Student activities:** The students' summarizes their discussion on a cardboard and tagged "students' ideas about measurement of acidity and alkalinity"**(8MINUTES)**.

**Step 3: Reformative Phase**

**Teacher activities:** The teacher interacts with students' prior knowledge. This is done through:

i. Extending prior knowledge where ideas are limited.

ii. Helping students to refine their ideas to scientifically validated ideas and re-emphasizes scientifically valid ideas.

**Student activities:** As the idea of each team is being explained by the leader of the group, alternative viewpoints are identified and students are thus helped to recognize and critically examine such alternative viewpoints.**(11MINUTES) REMEDIATION PHASE**

**Step 4: Application phase**

**Teacher activities:** The teacher asks question on how the knowledge of acids and bases can make them understand how acidity and alkalinity can be measured

**Student activities:** Students discuss the answer to the questions in their small groups and arrives at concrete suggestions on the measurement of acidity and alkalinity of solution.**(7MINUTES)**

**Step 5: Evaluation Phase**

**Teacher activities:** The teacher asks the following questions

i. What is pH

ii. Define the term indicator

iii. What do you understand by acid-base titration

iv. What is buffer solution

**Student activities:** Students gives responses to the questions raised by the teacher giving explanation in each case.**(7MINUTES)**

## Appendix VI

## LESSON PLANS FOR CONTROL GROUP

## LESSON PLAN ONE

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topics:** **Definition, classification and basicity of acids**

**Class:** **S S I**

**Gender:** **Mixed**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Duration:** **40minutes**

**Behavioral objectives:** by the end of the lesson the students should be able to:

6. Define acids
7. State the classes of acids
8. Describe how an acid behaves in solution.
9. Define the term basicity of an acid
10. State the basicity of some common acids

**Previous knowledge:** the students are familiar with soft drinks, lime and lemon.

**Introduction:** the teacher introduces the lesson by asking the students to taste lime and explain how it tastes.

**Presentation:** the teacher presents the lesson in the following steps

**Step1:** The teacher defines an acid as a substance which produces hydrogen ions when dissolved in water. And an acid can be recognized by its sour taste.

**Step2:** The teacher states the classes of acids as, i. organic acids ii. Mineral or inorganic acids

**Step3:** The teacher explains how an acid behaves in a solution as an acid dissolves in water to produce hydrogen ions, $H^+$ as the only positive ions, together with the corresponding negative ions. This process is called ionization.

**Step4:** The teacher defines the term basicity of acids as the number of replaceable hydrogen ions, $H^+$ in one mole of the acid.

**Step5:** the teacher further explains the basicity of some common acids as

1. $HCl_{(acid)}$ $H^+, Cl^-_{(ions\ produced)}$ 1 or monobasic $_{(basicity)}$
2. $H_2SO_4$ $_{(acid)}$ $2H^+, SO_4^{2-}{}_{(ions\ produced)}$ 2or dibasic $_{(basicity)}$

3. $H_3PO_4$ (acid) $3H^+$, $PO_4^{3-}$ (ions produced) 3 or tribasic (basicity)

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. Define acids
2. State the classes of acids
3. Describe how an acid behaves in solution.
4. Define the term basicity of an acid
5. State the basicity of some common acids

**Conclusion:** The teacher concludes the lesson by revising the major points of the lesson and giving the students home work.

## LESSON PLAN TWO

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topics:** **Properties of acids**

**Class:** **S S I**

**Gender:** **Mixed**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Duration:** **40minutes**

**Behavioral objectives:** by the end of the lesson the students should be able to:

3. State the physical properties of acids
4. Explain the chemical properties of acids

**Previous knowledge:** The students are familiar with the concept acids.

**Introduction:** The teacher introduces the lesson by asking the students base on the previous knowledge. Such as, define acids, state the classes of acids, describe how an acid behaves in solution and define the term basicity of an acid.

**Presentation:** The teacher presents the lesson in the following steps

**Step1:** The teacher explains the physical properties of acids as

1. Dilute acids have sour taste
2. Acids turn blue litmus red
3. The concentrated forms strong acids like HCl and $H_2SO_4$ are corrosive

**Step2:**The teacher states and explains the chemical properties of acids

1. Reaction with metals: acids react with some metals like zinc, iron and magnesium to liberate hydrogen gas.

   $2HCl\ (aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$

2. Reaction with bases: acids react with insoluble bases and alkalis to form salt and water as the only products. Such a reaction is known as neutralization.

   $2HCl\ (aq) + CaO(s) \rightarrow CaCl_2(aq) + H_2O(l)$

3. Reaction with trioxocarbonate(iv): acids react with trioxocarbonate(iv) to liberate carbon (iv) oxide.

   $2HCl\ (aq) + Na_2CO_3\ (aq) \rightarrow 2NaCl\ (aq) + H_2O(l) + CO_2(g)$

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. State the physical properties of acids
2. Explain the chemical properties of acids

**Conclusion:** The teacher concludes the lesson by summarizing the important points and giving the students home work.

## LESSON PLAN THREE

**Subject:** **Chemistry**

**Topic:** **Acids**

**Sub-topics:** **Methods of preparation and uses of acids**

**Class:** **S S I**

**Gender:** **Mixed**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Duration:** **40minutes**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

3. Outline the general methods for preparation of acids
4. List some of the uses of acids

**Previous knowledge:** The students are familiar with the concept of acids.

**Introduction:** The teacher introduces the lesson by asking the students base on the previous knowledge. What are the physical and chemical properties of acids.

**Presentation:** The teacher presents the lesson in the following steps

**Step1:** The teacher outlines the general methods for preparation of acids as:

1. Dissolving an acid anhydride in water
2. Combination of constituent elements
3. Using a strong acid to displace a weak acid or a volatile acid from its salt

**Step2:**the teacher lists some of the uses of acids

1. Used in food preservation
2. Needed by industries for making fertilizers, explosives etc
3. Used in making fruit juice
4. Used in making baking soda, soft drinks and health salts

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. Outline the general methods for preparation of acids
2. List some of the uses of acids

**Conclusion:** The teacher concludes the lesson by summarizing the important points and givingthe students home work.

## LESSON PLAN FOUR

**Subject:** **Chemistry**
**Topic:** **Bases**
**Sub-topics:** **Definition, classes and neutralization**
**Class:** **S S I**
**Gender:** **Mixed**
**Age:** **13-15yrs**
**Sex:** **males and females**
**Duration:** **40minutes**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

4. Define the concept base
5. State the classes of base
6. Define neutralization

**Previous knowledge:** The students are familiar with the concept of acids.

**Introduction:** The teacher introduces the lesson by asking the students base on the previousknowledge. Such as; outline the general methods for preparation of acids and list some of the uses of acids.

**Presentation:** The teacher presents the lesson in the following steps

**Step1:**The teacher defines base as a substance which will neutralize an acid to yield salt and water only. It is a substance that turns red litmus blue

**Step2:**The teacher classifies base as strong and weak base. Strong base like sodium and potassium hydroxideionize completely in aqueous solution to produce negatively charged hydroxide ions, OH, and positively charged metallic ions. Weak base like calcium oxide reacts with water to give a hydroxide which is only slightly soluble in water

**Step3:**The teacher defines neutralization as the combination of hydrogen ions, $H^+$, and hydroxideions, $OH^-$, to form water molecules $H_2O$. A salt is formed at the same time.

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. Define the concept base
2. State the classes of base
3. Define neutralization

**Conclusion:** The teacher concludes the lesson by summarizing the important points and givingthe students home work.

## LESSON PLAN FIVE

**Subject:** **Chemistry**

**Topic:** **Bases**

**Sub-topics:** **Properties and uses of base**

**Class:** **S S I**

**Gender:** **Mixed**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Duration:** **40minutes**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

4. List the physical properties of bases
5. List the chemical properties of bases
6. Mention some of the uses of bases

**Previous knowledge:** The students are familiar with the concept of bases.

**Introduction:** The teacher introduces the lesson by asking the students base on the previousknowledge. Such as, define the concept base, state the classes of base and define neutralization.

**Presentation:** The teacher presents the lesson in the following steps

**Step1:**The teacher states the physical properties of bases as follows;

1. Bases have a bitter taste
2. Bases are soapy to the touch
3. Bases turns red litmus paper blue
4. Concentrated forms of caustic bases are corrosive

**Step2:** The teacher states the chemical properties of bases as;

1. Reaction with acids: all bases react with acids to form salt and water only

   $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H2O(l)$

2. Reaction with ammonium salts: bases react with ammonium salts in the presence of heat to generate ammonia gas

   $Ca(OH)_2(aq) + 2NH_4Cl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + 2NH_3(g)$

**Step3:** The teacher mentions some of the uses of base as;

1. Used in the manufacture of soap, sodium salts and plastics
2. Used in dyeing and electroplating
3. Used in manufacture of toothpaste

4. Used for bleaching clothes

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. List the physical properties of bases
2. List the chemical properties of bases
3. Mention some of the uses of bases

**Conclusion:** The teacher concludes the lesson by summarizing the important points and givingthe students home work.

## LESSON PLAN SIX

**Subject:** **Chemistry**

**Topic:** **Acids and Bases**

**Sub-topics:** **Measurement of acidity and alkalinity**

**Class:** **S S I**

**Gender:** **Mixed**

**Age:** **13-15yrs**

**Sex:** **males and females**

**Duration:** **40minutes**

**Behavioral objectives:** bythe end of the lesson the students should be able to:

7. State what could be used to Measure the acidity and alkalinity of a solution
8. Define pH and state its importance
9. Describe the term indicator
10. Define an acid-base indicator
11. State an acid-base titration
12. Define a buffer solution

**Previous knowledge:** The students are familiar with the concept ofacids and bases.

**Introduction:** The teacher introduces the lesson by asking the students base on the previousknowledge. Such as;list the physical properties of bases, list the chemical properties of bases and mention some of the uses of bases.

**Presentation:** The teacher presents the lesson in the following steps:

**Step1:**Theteacher states what could be used to measure the acidity and alkalinity of a solution:the acidity and alkalinity of a solution can be measured using a scale of numbers from 0 to 14, called a pH scale.

**Step2:**The teacher defines pH as a measure of the concentration of hydrogen ions in a solutionor the measure of acidity and alkalinity of a solution.

**Step3:**The teacher describes what an indicator is: it is a weak organic acids or base whichproduce different colors in solution according to the hydrogen ion, $H^+$, concentration in that solution.

**Step4:**The teacher describes what an acid-base indicator is: it is a dye which changes color according to the pH of the medium.

**Step5:** During a titration, there is a change in the pH as the acid is added to alkali. The change in pH may be studied using a pH meter or by an indicator. The change in pH during the course of the titration depends on the strength of the acid and alkali used.

**Step6:**Theteacher defines what buffer solution is as: a solution which resists to changes in pH ondilution or on addition of small amounts of acids or bases.

**Evaluation:** The teacher evaluates the lesson by asking the students the following questions:

1. State what is used to Measure the acidity and alkalinity of a solution
2. Define pH and state its importance
3. Define the term indicator
4. Define an acid-base indicator
5. State what an acid-base titration is
6. Define buffer solution

**Conclusion:** The teacher concludes the lesson by summarizing the important points and givingthe students home work.

**Appendix VI:**
**Frequency and Percentage of Identified Misconceptions by the Students inprettest**

| Ideas being tested | Students alternative conception(misconceptions) | No of response | Type of misconception | Percentage |
|---|---|---|---|---|
| Describe what an acid is | -Acids burn and melt everything | 57 | Factual misconception | 57% |
| | -Acids are substances that can affect the body. | 56 | Preconceived notion | 56% |
| | - Taste of acid is bitter. | 50 | Preconceived notion | 50% |
| | - Any substance that contains the H atom is an acid, | 5 | Preconceived Notion | 5% |
| Examples of acids | -strong acid | 20 | - | 20% |
| | -weak acid | 51 | - | 51% |
| | -Moderate or neutral acid | 50 | Nonscientific belief | 50% |
| Classification of acids | -A strong acid is always a concentrated acid | 60 | Factual misconception | 60% |
| | -The only way to test a sample whether it is an acid or a base is to see if it eats something away, for example metal, plastic, animal, and us | 30 | Preconceived notion | 30% |
| | - Acids turn red litmus paper into blue. | 64 | Conceptual misunderstanding | 64% |
| Describe what a base is | -Taste of base is sour. | 45 | Factual misconception | 45% |
| | - Any substance that has an OH molecule is a base | 12 | Preconceived notion | 12% |
| Examples of base | -strong base | 60 | Conceptual misunderstanding | 60% |
| | -weak base | 47 | | 47% |
| | - Neutral base | 54 | | 54% |
| Classification of base | -soluble base | 9 | | 9% |
| | -insoluble base | 9 | | 9% |
| | -bases turn blue litmus paper into red. | 67 | Conceptual misunderstanding Preconceived | 67% |

| | | | | |
|---|---|---|---|---|
| | - Bases have only OH ions but not H ions | 59 | notion | 59% |
| pH and indicator | -pH is a measure of acidity | 68 | Preconceived notion | 68% |
| | -As the value of pH increases, acidity increases | 23 | Preconceived notion | 23% |
| | -Indicators help with neutralization | 41 | Preconceived notion | 41% |
| | -pH of pure water (distilled or de-ionised) is always equal to 7. | 8 | Preconceived notion | 8% |
| | -pH of a neutral solution is always 7. | 30 | Preconceived notion | 30% |
| | -A solution of 10-8 M HCI has a pH of 8. | 17 | Preconceived notion | 17% |
| | -Neutralization of acid and base always gives a neutral product. | 19 | Preconceived notion | 19% |
| | - PH is a measure of acidity. | 39 | Preconceived notion | 39% |
| | - POH is a measure of bassist. | 41 | Preconceived notion | 41% |
| | -As the value of PH increases, acidity increases | 33 | Preconceived notion | 33% |
| | - As the value of POH increases, bassist increases | 41 | Preconceived notion | 41% |

## Appendix VII:

## Frequency and Percentage of Identified Misconceptions by the Students at posttest

| Ideas being tested | Students alternative conception(misconceptions) | No of response | Type of misconception | Percentage |
|---|---|---|---|---|
| pH and indicator | -A solution of 10-8 M HCI has a pH of 8. | 34 | Preconceived notion | 32% |
| | - As the value of POH increases, bassist increases | 12 | Preconceived notion | 12% |

## Appendix VIII

## Samples of an Answered Acid and Bases Misconception Test (ABMT)

**Acids and Bases Misconception Test (ABMT)**

Instructions: Answer all questions. Write as precisely as possible with the space provided.

Candidates are at liberty to write their names or not.

Time allowed: 1hour

Name:

School: G. S.S Magajiya

Gender: Femal

1. Describe what an acid is a molecule or other species that can donate a proton or accept and electron pair in reaction
2. List two examples of acids strong acid weak acid
3. State the natural sources of acids Lime (Citrus fruit). milk (Lactic Acid.)
4. State the classification of acid Strong acid and weak in terms of basicity: Monobasic, dibasic and tribas
5. List three properties of acids Turns blue litmus paper red Some acid taste sour e.g Vinegar
6. Describe what a base is A base is a substance that can accept hydrogen ions from another substance
7. List two examples of bases
8. State the natural sources of bases? Vegetables
9. State the classification of base Arrhenius bases
10. List three properties of bases turn red litmus blue base are substance that in aqueous solution are slipp to the touch.
11. State what can be used in the laboratory to test acidic and basic substance

litmus paper

12. Define the term pH is a measure of hydrogen ion concentr of a solution.

13. How does pH measure the concentration of acids?

14. How does pH measure the concentration of bases

15. How does acids and bases reacts with each other

16. What is a strong base? A substance that is fully ionic

17. What is a weak base? dont ionise fully in an aqueous solution does not convert fully into hydroxide ions in solution

18. Describe the concept of POH is a measure of hydroxide ion.

19. What could be used to measure acidity and alkalinity of a solution

20. Describe what buffer solution means. a solution which resist changes in PH when acid or alkali is added to it.

## Acids and Bases Misconception Test (ABMT)

Instructions: Answer all questions. Write as precisely as possible with the space provided.

Candidates are at liberty to write their names or not.

Time allowed: 1hour

Name:

School: G.S.S Magayyi.

Gender: Female

1. Describe what an acid is Acid burn and melt things. ×
2. List two examples of acids Strong acid (ii) weak acid (iii) neutral or moderate acid ×
3. State the natural sources of acids
4. State the classification of acid strong acid is always very concentrated. ×
5. List three properties of acids
6. Describe what a base is Base is anything that is sour.
7. List two examples of bases (1) Strong base (2) weak base (3) moderate base ×
8. State the natural sources of bases?
9. State the classification of base soluble and insoluble base.
10. List three properties of bases base turns blue litmus paper red. ×
11. State what can be used in the laboratory to test acidic and basic substance

PH.

12. Define the term pH PH measures acidity

13. How does pH measure the concentration of acids? As the PH increases acidity increase.

14. How does pH measure the concentration of bases

15. How does acids and bases reacts with each other

16. What is a strong base? Very Strong Sour taste.

17. What is a weak base? Weak Sour taste

18. Describe the concept of POH POH measure bassist,

19. What could be used to measure acidity and alkalinity of a solution

20. Describe what buffer solution means.