UNIVERSITY OF EDUCATION, WINNEBA

USING PROBLEM-BASED LEARNING TO ENHANCE STUDENTS' PERFORMANCE IN THEIR STUDY OF THE MOLE CONCEPT

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DECLARATION

Student's Declaration

I, **Amma Fosua Biney,** hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been given due recognition and highly acknowledged, is my own work and the results of my own research and it has not been submitted either in part or whole, for another degree elsewhere.

SIGNATURE: ………………………

DATE:……………………………….

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines set for dissertations laid down by the University of Education, Winneba.

SUPERVISOR'S NAME: PROF. EMMANUEL K. OPPONG

SIGNATURE: …………………………

DATE:…………………………………

DEDICATION

This work is dedicated to my mother Miss Regina Ankama and my father Mr. S. Y. N. Biney whose toil and sweat have made me what I am today. It is also dedicated to my children Fiifi, Aseda, Jojo and my dearly beloved husband Rev. Benjamin Takyi.

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ABSTRACT

This study sought to enhance the academic performance of students in mole concept using problem-based learning instructional approach. The individual teacher action research strategy was adopted for the study in which the students were taken through four-weeks interactive lessons by the intervention of problem-based learning (PBL) as a teaching learning technique. The target population for the study was all general science students of Obiri Yeboah Senior High School in the Assin Foso Municipality of the Central Region. The accessible population was form two general science students of Obiri Yeboah SHS. Convenience sampling technique was used to select an intact class of thirty-nine (39) students which was made up of twenty-two (22) males and seventeen (17) females. The instrument used in data collection were the Pre and Post Mole Concept Achievement Test (MCAT) and Students pre and post Perception and Attitude towards mole concept Questionnaire (PREPAQ and POSPAQ). Data were analyzed using t-test, bar charts, pie charts and percentages. Hypotheses were accepted or rejected at a significant level of 0.05. The mean values for the pre-intervention and post-intervention test results were 19.43 and 31.60 respectively which indicates an improvement in academic performance of students. This shows that the students performed better after the intervention of PBL. To determine whether there was a significant difference between students' pre and post test scores a paired samples t-test was carried out which gave a significant difference between the pre and post test scores of students at a p value of 0.000 ($\alpha=0.05$). The results from the questionnaire also revealed that students' perception and attitude changed positively after the PBL intervention. Finally, the results from the t-test carried out on the scores between male and female students after the PBL intervention indicated that there was no significant difference between male and female scores at a p-value of 0.456($p > 0.05$). In view of these, it is recommended that teachers in Senior High Schools should be encouraged to use PBL as an instructional approach for teaching and learning to enhance students conceptual understanding and academic performance in mole concept.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter looked at the background to the study, statement of the problem, the purpose of the study, objectives of the study, research questions and hypothesis, significance of the study, delimitations and limitations of the study, the definition of terms and organization of the report.

1.1 Background to the Study

Chemistry is a branch of science that involves the study of the composition, structure and properties of matter. It is a creative discipline chiefly concerned with atomic and molecular structure and its change, for instance through chemical reaction. It is often known as the central science and the mother of all sciences because it plays a very significant role in unifying other science subjects (Agogo & Otor, 2013).

According to Burmeister and Eilks (2012), the relevance of chemistry in general education is widely acknowledged, making it one of the most significant subjects in the school curriculum. It is important to note that the field of chemistry, science and technology are related to the economic heart of every highly-developed, industrialized and technologically advanced society. Teaching and learning of science have significant roles towards technological development in a developing nation since chemistry is embedded in our life and society, economical, ecological and societal influences (Hofstein et al., 2011).

The study of chemistry is conceptual in nature. Students studying chemistry at the secondary school level or in colleges and universities are exposed to and need to understand a wide range of concepts. These concepts are central to understanding chemistry, hence the understanding of chemical concepts is therefore, a core concern in chemical education. However, understanding chemical concepts is not simple. Key concepts that students encounter in their study of chemistry are frequently not understood, understood only partially, or even misunderstood by students at all levels (Taber,2019).

The mole is one of the basic concepts that is required in almost every topic of the chemistry syllabus. According to Indriyanti and Barke (2017), the mole is an abstract sub-micro level concept and the basic knowledge needed to solve quantitative problems. The mole concept has been acknowledged as one of the most challenging subjects to teach and learn within the chemistry curriculum due to its abstract, theoretical nature. Indriyanti (2016), found that students fail to construct meaningful understandings of the mole concept because of the following: lack of problem-solving practice, inconsistent textbook and teacher pedagogical approaches, confusing mole concept vocabulary, students' math anxiety and proportional reasoning skills as well as learners' cognitive levels.

According to Vorsah and Adu-Gyamfi (2021), the mole is a concept at a sub-microscopic level whilst chemistry students' reasoning is at a macroscopic level and is based on their interactions with actual things connected to chemical processes. Therefore, teachers and students must avoid making semantic mistakes when teaching the mole concept due to what Pekdağ and Azizoğlu (2013) termed as the "missing concept, which cannot be located at either the macroscopic, microscopic, or symbolic level of representation, "For instance, how many moles are there in 8g of oxygen molecules is not represented at the macroscopic level and should be expressed as What is the amount of oxygen, O_2, in a sample of 8g element $O_{2(g)}$? Additionally, this would guarantee that the phrases are coherent with the definition of the mole.

Students and teachers encounter a lot of challenges during the teaching and learning of the mole concept (Indriyanti & Barke, 2017). The mole is a very important concept and failing to understand it completely makes it difficult to understand the following concepts, particularly stoichiometry problems including volumetric calculations and concentration of solutions (Childs & Sheehan, 2009). Students persistently low performance can be attributed to the teaching and instructional methods adopted by science teachers. According to Ifemuyinwa (2008), the persistent use of traditional instructional approaches has been observed as a major challenge to students proper understanding, assimilation and retention of content taught which is affecting learning and higher achievement in science.

The most commonly used traditional teaching methods in our science classrooms include lectures, tutorials, demonstrations and laboratory classes. Most of them involve teacher centred teaching. Students receive knowledge passively. These traditional methods do not stimulate their interest in the subject. Methodology is very vital in any teaching-learning situation. The method adopted by the teacher may promote or hinder learning. Teaching methods are ways to help students learn effectively. It may sharpen mental activities which are the bases of social power or may discourage initiative and curiosity thus making self-reliance and survival difficult (Ameh & Dantani, 2012). A student's ability to reason, think critically, and apply their knowledge of science is aided by their understanding of chemical concepts. Hence students should be taught chemistry in a way that helps them understand the basic principles of chemistry.

Many kinds of research show that student-centred learning is effective for every member of the classroom. This is because it takes into account their diverse learning needs and greatly increases their retention of both knowledge and skills. Teaching difficult concepts like the mole calls for a teaching strategy or approach that is learner-centred and innovative enough to facilitate learners' interest. There are several teaching learning strategies that are student centred, one of them is problem-based learning (PBL).

PBL is considered as one of the most innovative instructional methods to date (Aidoo et al., 2016). By using this approach, teachers become only facilitators who direct the learning process, while students become independent learners. These elements differ significantly from conventional teaching strategies. PBL encourages deeper knowledge, develops lifetime learning abilities and increases retention, all of which are enjoyable and meaningful for the majority of students (Jimoh & Fatokun, 2020).

1.2 Statement of the Problem

The mole concept is a basic concept taught at the first-year level in SHS in Ghana as part of the general chemistry syllabus. One of the aims of chemistry education in Ghana is to help students to demonstrate an understanding of the mole concept and its importance to the quantitative study of chemical reactions (MOE, 2010). However, the researcher observed that chemistry students of Obiri Yeboah Senior High School are not able to perform well in the mole concept especially when it comes to the application of the mole in solving quantitative questions.

Moss and Pabari (2010), attribute students' difficulty in applying the mole to a lack of proper understanding of the concept. According to Ifemuyiwa and Ajilogba (2012), the teaching method employed by a teacher reflects on students' understanding and performance in the subject. There is, therefore, the need for teachers to vary their methods and strategies of teaching so as to help students understand the mole concept. Problem-based learning as one of the instructional strategies is fast gaining ground as it has proven to be an effective teaching method that improves learners' performance. It is against this background that the study seeks to use the problem-based learning intervention to enhance students' conceptual understanding and academic performance in the mole concept.

1.3 Purpose of the Study

The purpose of this study was to use problem-based learning instructional approach to enhance academic performance of students in mole concept.

1.4 Objectives of the Study

The objectives of the study were to:

1. evaluate the academic performance of students on the mole concept after using a problem-based learning (PBL) instructional approach.
2. determine if there is any significant difference in the academic performance of students on mole concept after using a problem-based learning instructional approach.
3. find out whether there is a significant difference between the academic performance of males and females in mole concept after using PBL instructional approach.

4. to find out the perception and attitude of students towards the mole concept before and after using the problem-based learning instructional approach?

1.5 Research Questions

The following questions guided the study:

1. What effect would the use of a problem-based learning instructional approach have on the academic performance of students on the mole concept?
2. Is there any significant difference in the improvement in the academic performance of students in the mole concept after using a problem-based learning instructional approach?
3. Is there any significant difference in the academic performance between males and females on the mole concept after using a problem-based learning instructional approach to teach the mole concept?
4. What are the perceptions and attitude of learners towards the mole concept before and after using the problem-based learning instructional approach?

1.6 Research Hypothesis

The research tested the following null hypothesis at a 0.05 significance level (α):

***Ho*₁:** There is no significant difference in the academic performance of students in the mole concept before and after using a problem-based learning instructional approach.

***Ho*₂:** There is no significant difference in the academic performance between males and females after using problem-based learning in teaching the mole concept.

1.7 Significance of the Study

The success of using a problem-based learning approach in the teaching and learning of the mole concept would give curriculum developers a new perspective in recommending its use across the educational system. The study would be useful to the Ghana Association of Science Teachers (GAST) in educating its members, especially chemistry teachers in adopting effective teaching methods for teaching the mole concept during their annual conferences or workshops. This study will help chemistry teachers to adopt teaching strategies that would help to sustain the attention and interest of students during the teaching and learning of the mole concept. The findings of this study would also help clear the negative perceptions that students have about the mole concept and also add to the existing knowledge on problem- based learning and its effect on students' performance on the mole concept.

1.8 Delimitations

Delimitations are the limitations or boundaries consciously set by the researcher so that the aims and objectives of the study can be achieved (Theofanidis & Fountouki, 2019). The study was carried out at Obiri Yeboah Senior High School in the Assin Foso Municipality of the Central Region due to of lack of funds, time constraints, convenience and accessibility of the population. There are many areas to research in chemistry but this study was focused on an aspect of chemistry, which is the mole concept. The study also restricted itself to the use of achievement tests and questionnaires in collecting data.

1.9 Limitations

According to Dusick (2011), a research's limitations are those aspects over which the researcher has no control. One of the factors that have affected the research's conclusions is the absenteeism of some students during the period of study. Naturally, this will have an impact on the study's findings and the collaboration of data. Also, the period for the study was only four weeks due to the short period of stay in schools by the new academic calendar. A longer period of study may have perhaps produced different results.

1.10 Operational Definition of Terms

Challenge - the situation of being faced with something that needs great mental effort in order to be done successfully and therefore tests a person's ability.

Concept – ideas that help to understand scientific phenomena, principles, laws and theories.

Gender differences - these are the differences as a result of being either a female or a male arising from the social and cultural construction of roles associated with these differences.

Mole concept - is a quantitative unit that provides a description of the amount of substances reacting together, and the amount of their corresponding products in a reaction medium.

Performance - scores in a test.

Pre-test - a test that learners will take before being exposed to a teaching strategy.

Post-test - is a test that learners will take after being exposed to a particular teaching strategy.

Problem-based learning - is a student-centred pedagogy in which students learn about a subject through the experience of solving an open-ended problem .

The traditional approach - is a method of instruction that strictly adheres to textbook material without taking the knowledge of the student into account.

1.11 Abbreviations

GES - Ghana Education Service

M.O.E - Ministry of education

PBL - Problem-based learning

S.H.S - Senior High School

1.12 Organization of the rest of the Study

The study was organized into five chapters.

Chapter one which is the introduction comprises of the background to the study, the statement of the problem, the purpose of the study as well as the research questions and hypothesis which guided the study. It also covered the significance of the study, limitations, delimitations of the study, definition of terms and abbreviations and ended with the organization of the rest of the study.

Chapter two reviewed the literature which was related to the study. It covered the theoretical and the empirical framework of the study.

Chapter three covered the research design and methodology, the population under study, the sample, the sampling techniques, the data collection instrument, the reliability and validity of the research instrument, the intervention, the data collection procedure and the mode of analysing the data.

Chapter four presents the data collected, their analysis and the discussion of the results that came out from the analysis of the data collected.

Chapter five presents the summary of the findings, the conclusions and the recommendations resulting from the outcomes of the study as well as suggestions for further studies.

1.13 Summary

The purpose of this study was to enhance academic performance of students in mole concept using problem-based learning instructional approach. Considering the important role that the mole concept plays in chemistry and the universal difficulty it poses to both teachers and students, finding methods that will render the mole concept simpler and improve students' thorough understanding of it was very crucial. As a result, it was necessary to examine critically the way chemistry is taught in Ghanaian senior high schools, as this is thought to be a key factor in both student performance and attitude toward the subject. The lecture method where the teacher delivered his/her already prepared notes to students is the technique mainly used by teachers in most SHS. The research focussed on a technique (PBL) where the students are at the centre of the teaching and learning process. PBL could help students to improve their understanding and performance in mole concept. The research was delimited to only form two (2) science students of Obiri Yeboah Senior High School.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter contains the review of the literature related to the study under two main areas: the theoretical and empirical frameworks.

The theoretical framework of this study is focused on the constructivist theory of learning. The empirical review was done under the following areas: Concept of Problem-based learning, The mole concept, Action research, Influence of attitudes and perception on performance, Conceptions and sources of misconceptions among students, Traditional and modern methods of teaching science as well as Gender and performance.

2.1 The Theoretical Framework of the Study

The theoretical framework of a study is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study exists (Abend, 2008). The theoretical framework of this study focussed on the constructivist theory of learning. It was reviewed under the following areas: Concept of constructivism, Principles of constructivism, Types of constructivism, Constructivist perception of nature of the learner, Role of the teacher in a constructivist classroom, Features of a constructivist classroom, Pedagogical goals of constructivist classrooms, Criticisms of constructivism, Constructivist teaching strategies and the Benefits of constructivism.

2.1.1 Concept of constructivism

The latest catchword in educational circles is "constructivism”. Constructivism is a major learning theory, and is particularly applicable to the teaching and learning of science because it helps students to build their own understanding of science (Sridevi, 2008). The basic premise of constructivist theory is that people are said to learn when they have gained experience from what they learn. That is, people create their own meaning through experience. Constructivist thinking is rooted in several aspects of Piaget and Vygotsky’s cognitive theories. From Piaget, we learn actively, create schemes, assimilate and accommodate all forms of science, etc. From Vygotsky, we get social constructivism, group work, internships, and so on. Thus, we can say that the “top -down” and” bottom-up” learning methodology is born of constructivism thinking. This means that the teacher will give the main idea then the students will get the details. In this thinking, the teacher does not teach the detail so that students will find it difficult to find an understanding of the details (Aljohani, 2017).

Elliott et al. (2000) states that constructivism is an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner. Constructivism is a synthesis of multiple theories diffused into one form. It is the assimilation of both behaviouralist and cognitive ideals. Merriam and Caffarella (1999) maintains that learning in constructivism is a process of constructing meaning; it is how people make sense of their experience. This is a combination effect of using a person’s cognitive abilities and insight to understand their environment. Constructing meaning is learning; there is no other kind. The dramatic consequences of this view are twofold:

1) We have to focus on the learner in thinking about learning (not on the subject/lesson to be taught).

2) There is no knowledge independent of the meaning attributed to experience (constructed) by the learner, or community of learners.

This concept is easily translated into a self-directed learning style, where the individual has the ability to take in all the information and the environment of a problem and learn. Constructivism reflects the organismic world view (Goldhaber, 2000), compared with behaviourism which is originated from the mechanistic world view; constructivism concerns how change occurs in development. For behaviourists, change comes about when an external force acts upon an object that is inherently at rest. For organismic theorists, behavioural change is inherent in the living organism itself rather than extremely driven.

2.1.2 Principles of constructivism

These are the main principles of constructivism

- Knowledge is constructed, rather than being innate, or passively absorbed.

Constructivism's central idea is that human learning is constructed, that learners build new knowledge upon the foundation of previous learning. This previous knowledge influences what new or modified knowledge an individual will construct from new learning experiences.

- Learning is an active process.

Learning is an active rather than a passive process. Contrary to constructivism, which claims that learners can only create meaning by active engagement with the environment, the passive approach of education sees the learner as "an empty vessel" to be filled with knowledge (such as experiments or real-world problem solving).

Understanding, however, cannot be passively acquired; rather, it must result from the creation of meaningful connections between previously held knowledge, newly acquired knowledge, and the learning processes themselves.

- All knowledge is socially constructed

Learning is a social activity - it is something we do together, in interaction with each other, rather than an abstract concept. For example, Vygotsky (1978), believed that community plays a central role in the process of "making meaning." For Vygotsky, the environment in which children grow up will influence how they think and what they think about. Thus, all teaching and learning is a matter of sharing and negotiating socially constituted knowledge. According to Vygotsky (1978), cognitive development stems from social interactions from guided learning within the zone of proximal development as children and their partner's co-construct knowledge.

- All knowledge is personal

Each individual learner has a distinctive point of view, based on existing knowledge and values. This means that same lesson, teaching or activity may result in different learning by each pupil, as their subjective interpretations differ. This principle appears to contradict the view that knowledge is socially constructed. Fox (2001) argues (a) that although individuals have their own personal history of learning, nevertheless they can share in common knowledge, and (b) that although education is a social process, powerfully influenced by cultural factors, nevertheless cultures are made up of sub- cultures, even to the point of being composed of sub-cultures of one. Cultures and their knowledge-base are constantly in a process of change and the knowledge stored by individuals is not a rigid copy of some socially constructed template. In learning a culture, each child changes that culture.

- Learning exists in the mind

According to the constructivist idea, knowledge can only exist in human minds and need not correspond to any actual reality (Driscoll, 2000). Students will continually work to create their own unique mental models of the real world based on how they see that environment. Learners constantly revise their mental models to reflect new knowledge as they experience each new thing, creating their own version of reality in the process.

The principles above shows that in constructivism meaning or understanding is achieved by assimilating information, relating it to our existing knowledge and cognitively processing it (in other words, thinking or reflecting on new information). Fig 2.1 below presents the framework for the constructivist' learning theory.

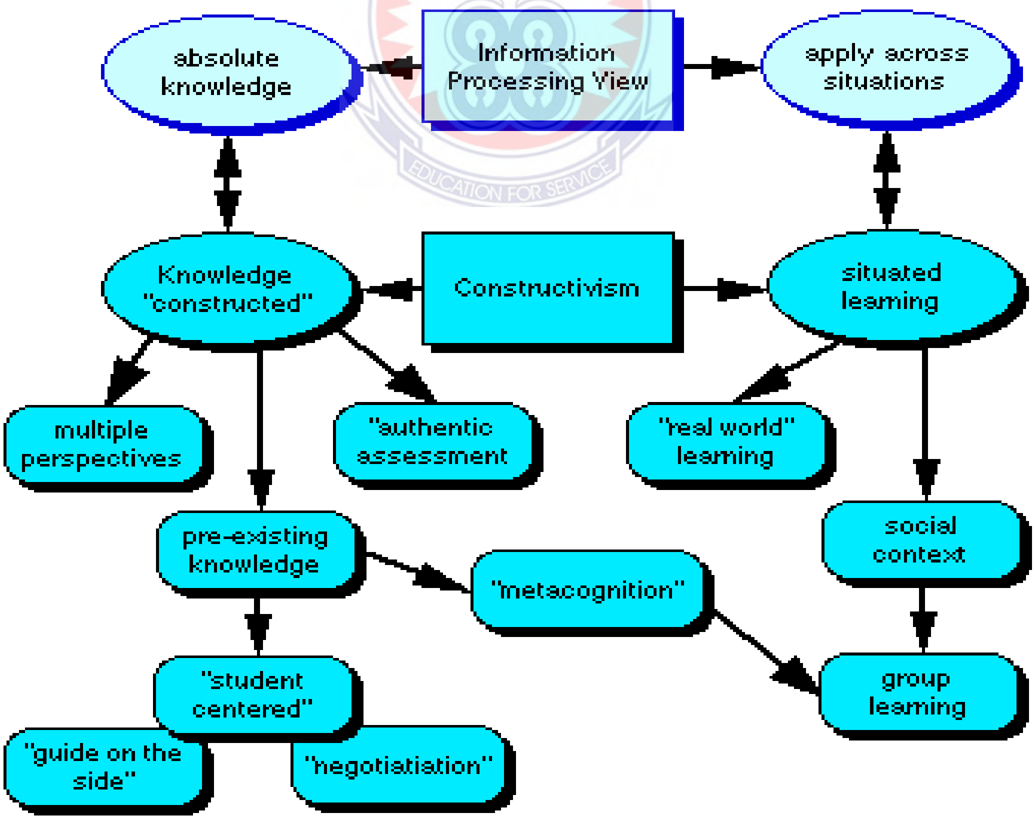


Fig 1: Framework for Constructivist Learning Theory

2.1.3 Types of constructivism

According to the GSI Teaching and Resource Centre (2015): there are three (3) types of Constructivism :Cognitive constructivism based on the work of Jean Piaget, social constructivism based on the work of Lev Vygotsky, and radical constructivism by Ernest von Glasersfeld .

Cognitive constructivism developed by Jean Piaget states knowledge is something that is actively constructed by learners based on their existing cognitive structures. Therefore, learning is relative to their stage of cognitive development. Cognitivist teaching methods aim to assist students in assimilating new information to existing knowledge, and enabling them to make the appropriate modifications to their existing intellectual framework to accommodate that information.

According to social constructivism learning is a collaborative process, and knowledge develops from individuals' interactions with their culture and society. Social constructivism was developed by Vygotsky (1978) who suggested that, every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). Social constructivism recognizes the importance of the background and culture of the learner; thus, they encourage the learners' social interaction with knowledgeable members of the society. This will enable the learner to acquire social meaning of important symbol systems and learn how to utilize them. The constructivists encourage young children to develop their thinking abilities by interacting with other children, adults and the physical world.

The idea of radical constructivism was developed by Von Glasersfeld (1974) and states that all knowledge is constructed rather than perceived through senses. Learners construct new knowledge on the foundations of their existing knowledge. However, radical constructivism states that the knowledge individuals create tells us nothing about reality, and only helps us to function in your environment. Thus, knowledge is invented not discovered. The humanly constructed reality is all the time being modified and interacting to fit ontological reality, although it can never give a 'true picture' of it.

2.1.4 Constructivist perception of nature of the learner

The constructivist perception of nature of the learner is as follows:

1. The constructivists see the learner as a unique individual with unique needs and backgrounds.
2. The learner is also seen as a complex individual hence he should be regarded as an integral part of the learning process.
3. Learners with different skills and backgrounds should collaborate in tasks and discussions to arrive at a shared understanding of the truth in a specific field.

2.1.5 Role of the teacher in a constructivist classroom

The constructivist theory's main theme is that learning is a process in which the learner is able to build on present and previous information (Brandon & All,2010). The student is able to take information, create ideas and make choices by utilizing a thought process. The trainer should encourage the student to develop the skills to find out principles on their own. There should be on-going dialog between the student and the trainer. The trainer is responsible for making sure the information is in a format the student can comprehend. The key is to ensure that the course builds on what has already been learned. Constructivists think that learners build knowledge actively through the interactions with environmental stimuli. In other words, learning focuses on the learners' questions and exposure. Assessment should avoid standardized tests and grades such as achievement tests designed with multiple choices to test subject-specific knowledge. Assessment appears in the learning process, so students play an important role.

The primary responsibility of the teacher is to create a collaborative problem-solving environment where students become active participants in their own learning. From this perspective, a teacher acts as a facilitator of learning rather than an instructor. The teacher makes sure he/she understands the students' pre-existing conceptions, and guides the activity to address them and then build on them (Oliver, 2000).Scaffolding is a key feature of effective teaching, where the adult continually adjusts the level of his or her help in response to the learner's level of performance. In the classroom, scaffolding can include modelling a skill, providing hints or cues, and adapting material or activity (Copple & Bredekamp, 2009).

Contrary to criticisms by some (conservative/traditional) educators, constructivism does not dismiss the active role of the teacher or the value of expert knowledge. Constructivism modifies that role, so that teachers help students to construct knowledge, rather than to reproduce a series of facts. Constructivism is also often misconstrued as a learning theory that compels students to "reinvent the wheel." In fact, constructivism taps into and triggers the student's innate curiosity about the world and how things work. And then, students create organizing principles that they can take with them to other learning settings. The social constructivist sees the role of the science teacher as a facilitator rather than a teacher.

According to Gamoran et al. (2000) a teacher strives a didactic lecture that covers the subject matter while a facilitator helps the learner to get to his or her own understanding of the content. In teacher scenario, the learners are very passive in the learning process while in the facilitator scenario; the learners are actively involved in the learning process. The constructivist sees learning as a social process where the learners interact among themselves thereby making learning meaningful. Again, the constructivist believes that there is dynamic interaction between the learning task, the instructor, and the learner. The role of the facilitator is to encourage the dynamic interaction. The above implies that the instructor and the learners are equally involved in learning from each other (Holt & Willard- Holt, 2000).

2.1.6 Features of a constructivist classroom

According to Tam (2000) the following four basic characteristics of constructivist learning environments, must be considered when implementing constructivist teaching strategies:

1) Knowledge will be shared between teachers and students.

2) Teachers and students will share authority.

3) The teacher's role is one of a facilitator or guide.

4) Learning groups will consist of small numbers of heterogeneous students.

The difference between traditional and constructivist classrooms are presented in Table 1 below.

Table 1: Differences between a Traditional and Constructivist Classroom

Traditional Classroom	Constructivist Classroom
Strict adherence to a fixed curriculum is highly valued.	Pursuit of student questions and interests is valued.
Learning is based on repetition.	Learning is interactive, building on what the student already knows.
Teacher centred	Student centred
Teachers disseminate information to students; students are recipients of knowledge (passive learning).	Teachers have a dialogue with students, helping students construct their own knowledge (active learning).
Teachers' role is directive, rooted in authority.	Teachers' role is interactive, rooted in negotiation.
Students work primarily alone (competitive).	Students work primarily in groups (cooperative).

2.1.7 Pedagogical goals of constructivist classrooms

The following are the pedagogical goals of constructivist learning environment (Honebein, 1996):

1) To provide experience with the knowledge construction process (students determine how they will learn).

2) To provide experience in and appreciation for multiple perspectives (evaluation of alternative solutions).

3) To embed learning in realistic contexts (authentic tasks).

4) To encourage ownership and a voice in the learning process (student centred learning).
5) To embed learning in social experience (collaboration).
6) To encourage the use of multiple modes of representation, (video, audio text, etc.)
7) To encourage awareness of the knowledge construction process (reflection, metacognition).

Brooks and Brooks (1999) list twelve descriptors of constructivist teaching behaviours:

1. Encourage and accept student autonomy and initiative. (p. 103)
2. Use raw data and primary sources, along with manipulative, interactive, and physical materials. (p. 104)
3. When framing tasks, use cognitive terminology such as “classify,” analyse,” “predict,” and “create.” (p. 104)
4. Allow student responses to drive lessons, shift instructional strategies, and alter content. (p. 105)
5. Inquire about students’ understandings of the concepts before sharing [your] own understandings of those concepts. (p. 107)
6. Encourage students to engage in dialogue, both with the teacher and with one another. (p. 108)
7. Encourage student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other. (p. 110)
8. Seek elaboration of students’ initial responses. (p. 111)
9. Engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion. (p. 112)
10. Allow wait time after posing questions. (p. 114)

11. Provide time for students to construct relationships and create metaphors. (p. 115)
12. Nurture students' natural curiosity through frequent use of the learning cycle model. (p. 116).

2.1.8 Constructivist teaching strategies

Constructivist teaching is based on constructivist learning theory. Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. Learners are the makers of meaning and knowledge. Constructivist teaching fosters critical thinking, and creates motivated and independent learners. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema. Constructivism gives teachers another perspective to rethink how students learn and to focus on process and provide ways of documenting change and transformation. It also reminds teachers to look for different ways to engage individual student, develop rich environments for exploration, prepare coherent problem sets and challenges that focus the model building effort, elicit and communicate student perceptions and interpretations.

Constructivist teaching practices are becoming more prevalent in teacher education programs and public schools across the nation, while demonstrating significant success in promoting student learning (Davis & Sumara, 2002). Teaching strategies using social constructivism as frame of reference relate to teaching in context that might be personally meaningful to student. These also involve negotiating understanding with students through class discussion in small as well as large groups of students.

According to Honebein (1996); Wilson & Cole (1991); Jonassen (1991):

The constructivist's teaching strategies are as follows that:

1. learning is best accomplished using a hands-on approach;
2. learners learn by experimentation and not by being told what will happen;
3. learners should be left to make their own discoveries, inferences and conclusions;
4. teachers should commence their teaching by building upon the previous knowledge that the learner possesses;
5. teacher's role is not only to observe and assess but to also engage the students while they are completing activities;
6. teachers are also to intervene when there are conflicts that arise in the course of their learning. They should facilitate the students' resolution and self-regulation, with an emphasis on the conflict.

On the basis of the above assertions by the constructivist, the following teaching strategies or approaches are recommended (Wilson and Cole (1991); Inquiry-based learning; problem-based learning; hands-on teaching approach; collaborative or group work; and cooperative learning, Reciprocal teaching/learning among others.

Reciprocal teaching/learning: a group of two or more students work together and teach one another.

Inquiry-based learning: students create their own questions and seek to solve them through research and observations. After underlining the arguments for their response, they make connections between their prior knowledge and the information discovered through their research. Students conclude by identifying possible gaps and developing further questions for the next project.

Problem-based learning: similar to inquiry-based learning, except focuses on problems in the real world. Students work in groups to research possible solutions and gain valuable skills by working together. Seeking evidence, making connections, and drawing conclusions as a team help students develop communication and collaborative skills while solving real-world issues.

Cooperative learning: small group activity with one key difference – interdependence. While most constructivist activities rely on group learning, cooperative activities are where group members are dependent on others to achieve solutions. There is no division of tasks in cooperative learning; instead, group members rely on the knowledge of others to further their own understanding.

Hands-on- teaching approach: is a process of instruction where students are directed to gain knowledge by self-experience. This means gives the students the opportunity to manipulate the objects while studying, for instance, plants, rocks, water, magnetic field, scientific instruments, calculators and shapes or it can be an exhibit.

Collaborative learning is the educational approach of using groups to enhance learning through working together. Groups of two or more learners work together to solve problems, complete tasks, or learn new concepts.

Today, there is a trend for incorporating technology into the classrooms to support instructional learning methods. Yet, recent studies have revealed technology is not effectively integrated with the concepts of constructivism (Hare et al.,2005). Nevertheless, constructivist methods of instruction with using computer technology have developed to meet the instructional goals and conditions. One of the most powerful and versatile tools is the web-based learning

2.1.9 Benefits of constructivism

Constructivism promotes a sense of personal agency as students have ownership of their learning and assessment (Rovai,2004). Children tend to enjoy themselves more, and therefore learn more, when they are engaged and active in the learning process. Below are some benefits that student enjoy in a constructivist classroom:

- Learning is cemented when the process is focussed on thinking and understanding rather than rote memorisation.
- As constructivism encourages students to explore and find answers for themselves, it gives students a sense of ownership over their learning.
- Constructivist learning is a transferable skill, and students can take the skills they learn in the classroom out into the real world.
- Constructivist learning is grounded in authentic, life-like activities, such as role-plays, which can be highly engaging for the students and can encourage them to explore the wider world further.
- Constructivism encourages students to collaborate and exchange ideas, promoting social and communicative skills. To contribute successfully, students must learn how to negotiate, organise their ideas, and listen to one another.

2.1.10 Criticisms of constructivism

One of the most prominent criticisms of a constructivist approach to teaching is that it often lacks structure as constructivist learning focuses on student-led methods and the teacher adopts a facilitator role. However, some students may struggle with this approach and may require a more structured and organised environment to thrive. Gupta (2011) criticises the constructivist approach as dominant children often control interactions within the classroom, and 'average' or shy children may be left behind. The biggest disadvantage is its lack of structure. Some students require highly structured learning environments to be able to reach their potential. It also removes grading in the traditional way and instead places more value on students evaluating their own progress, which may lead to students falling behind, as without standardized grading teachers may not know which students are struggling.

In summary, in a constructivist learning environment, students are actively involved in student–centred learning activities, classes tend to be less rigid in their structure and students are engaged in achieving the learning outcomes (Jonassen, 1999). Group work and discussion are integral parts of a constructivist's classroom, and students are encouraged to seek information for themselves and from their peers (Littleton et.al., 2006). Hence, the teacher's role changes from that of dispenser of information to a facilitator of information. Classes are designed to promote discussion, active learning, and reflection, and provision is made for modelling, coaching and scaffolding to support students when required. The learning process also requires the full engagement of the students in practical and real-world tasks. Finally, there are opportunities for students to reflect on their learning experiences (Jonassen, 1999).

2.2 Concept of Problem-Based Learning

Problem-Based Learning or PBL is a well-known approach among students, educators and researchers. PBL approach which had been introduced by Howard Barrows is an innovative teaching strategy where the teaching manner is shifted from teacher driven to student driven by emphasizing the development of problem solving, creativity and critical thinking skills (Hasna, 2009). PBL is defined as a progressive active learning and learner centred approach where unstructured problems are used as the starting point and anchor for the learning process (Tan, 2003). As the name implies, PBL begins with a problem and that problem becomes the main focus in PBL from which all progress, plan and work done by the students is directed towards solving the problems. PBL was firstly introduced in medical courses in 1969 to enhance the quality of medical education by moving from a subject and lecture-based curriculum to an integrated curriculum structured through real-world problems which cross traditional boundaries and it is now being widely used all over the world.

PBL is an innovative learning approach that is based on constructivism learning theory where the learning process is driven by the students (Noordin et al.,2011). The PBL method requires students to become responsible for their own learning. The PBL teacher is a facilitator of students' learning and his/her interventions diminish as students progressively take on responsibility for their own learning processes. This method is characteristically carried out in small, facilitated groups and takes advantage of the social aspect of learning through discussion, problem solving, and study with peers. The facilitator guides students in the learning process, pushing them to think deeply and models the kinds of questions that students need to be asking themselves, thus forming a cognitive apprenticeship. As a cognitive apprenticeship, PBL situates learning in complex problems (Hmelo-Silver, 2004).

As PBL has shown its effectiveness, this approach has later been accepted and adopted by various disciplines such as business, mathematics, science, psychology and engineering as well. Researchers all over the world have proven that the PBL approach is much better than traditional approach because it produces better and wellequipped students. Bilgin et al. (2015) as well as Ghufron and Ermawati (2018) all conclude that PBL not only conveys knowledge, but simultaneously develops transfer and problem-solving skills. According to Scholkmann (2016), PBL is among the best known teaching concepts that places human experience at the centre of learning .In this context, the complexity due in higher education learning is based on three dimensions (Scholkmann, 2016, p. 7): • with respect to time, by linking the learning situation to previous knowledge or the learner's own experiences, • with respect to inter- or transdisciplinary concepts, by describing a problem that involves several disciplines, and • with respect to naturalism, by selecting a dilemmatic phenomenon for which there is no simple technical or morally unambiguous solution. These three dimensions influence teaching and learning at different levels. They may, therefore, impact the design of teaching concepts.

Savery and Duffy (1995) explicitly state that the learning goals of PBL are related to self-directed learning, content knowledge, and problem solving. Self-directed learning entails competence in essential skills of literacy and numeracy, information location and retrieval, goal setting, time management, question-asking behaviour, critical thinking and comprehensive monitoring and self-evaluation. Self-directed learning skills assist students to become sensitive to their learning needs and to enhance their abilities in locating and using appropriate information resources. In order to solve a specific problem, students need to use and apply what they know about the problem and about the solution. The problem-based learning environment establishes the relevance between knowledge and its use. The interaction between the problem and use of knowledge fosters a deeper understanding of the content knowledge. Moreover, through social negotiation with the group members, students have opportunities to compare and evaluate their understanding of subject matters with others' understanding. All these facilitate students' learning and understanding of the content.

PBL enables the student to learn new knowledge by challenging him/her with the problems to be solved, instead of being burdened with contents (Çuhadaroglu et al., 2003). By means of problem-based learning, some attitudes of students in relation to such areas as problem-solving, thinking, group works, communication, information acquisition and sharing with others are affected. One of PBL's targets is to strengthen the students' personal responsibility. This makes the acquisition of knowledge more sustainable and improves the students communicative and social skills. The academic teachers support the students by coaching and facilitating teamwork, creative problem solving and other PBL-related strategies set in situations that resemble those typical of their future professional field. This allows students to successfully develop relevant competences for their future professional lives. In addition to learning through problem-solving, observing their teachers apply their knowledge and competence in simulated situations instead of passively listening to a monological lecture offers the students an excellent opportunity to witness and understand underlying processes and to subsequently apply the gained knowledge themselves. Hence, the relationship to their academic teachers influences the students' learning significantly.

Barrows (1996) identifies six core characteristics of problem-based learning that distinguish PBL. The first characteristic is that learning needs to be student-centred. Secondly, learning has to occur in small student groups under the guidance of a tutor. Thirdly, the tutor is referred to as a facilitator or guide. Fourth, authentic problems are primarily encountered in the learning sequence before any preparation or study occurs. The fifth characteristic is that the problems encountered are used as a tool to achieve the required knowledge and the problem-solving skills necessary to eventually solve the problem. The last and sixth characteristic of PBL is that new information needs to be acquired through self-directed learning. Dorchy et al. (2003) add a seventh characteristic, students learn by analysing and solving representative problems.

2.2.1 Problem-based Learning and Constructivism

PBL is extremely consistent with constructivist philosophy. It is identified as a constructivist-learning environment. Learning principles of PBL are explained from both cognitive and socio-cultural constructivist perspectives. According to Cheaney and Ingebritsen (2005), PBL is pedagogically suited to many different types of constructivism including the Piagetian cognitive constructivism, radical constructivism (in which PBL can be incorporated with cognitive apprenticeship), situated constructivism and co-constructivism (in which PBL can be incorporated with reciprocal teaching). The function of the ‘problems’ in the PBL approach as the trigger to the cognitive processes of accessing prior knowledge, establishing information into knowledge that both fits into and shapes new mental models echoes Piaget's concept of equilibration, a dynamic process of self-regulated process (Evensen & Hmelo, 2001). Underlying the concept are the assumptions that cognitive structures generate new possibilities when disturbed, and subsequent reflection brings about a structural change.

Similarly, PBL reflects Vygotsky's socio-historical development psychology. Learning results from the participation of the dialectical activity between the individual and society. From the constructivist view of learning underlying PBL, the knowledge is temporary, developmental, non-objective, internally constructed, socially and culturally mediated. Learning from this perspective is viewed as a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights. These construct new representations and models of reality as a human meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate (Fostnot, 2013).

The instructional principles of PBL in a constructivist framework according to Savery and Duffy (1995) are as follows:

1. In PBL, students are encouraged and expected to think both critically and creatively with multi-directional interactions with the problem, the peers, the resources, and the instructor. Learning is no more a process of transmitting information from others to the learners themselves, but a process of immersing themselves into a problem situation to actively engage in and monitor their own understanding.
2. In PBL, all the learning arises out of consideration of a problem and discussing the problem in class, generating hypotheses, identifying relevant facts related to the problem, identifying learning issues based on their analysis of the problem
3. In PBL, social negotiation of meaning is an important part of the problem-solving team structure. Students' understanding of the content is constantly challenged and tested by others.

2.2.2 Assessment in problem-based learning

The style of assessment which normally reflects students' choices of "right" or "wrong" answers cannot be appropriately used in evaluating learners' performance in learning through a PBL approach. Tchudi and Lafer (1996) claim conventional assessment is a game that asks the learner to guess what the teacher wants rather than perform the best they can. It is difficult to use traditional tests to assess the outcomes the learners gain from the learning through a PBL approach such as skills of problem-solving, critical thinking, creativity, self-directed learning, teamwork and communication. Reynolds (1997) argues that PBL assessment needs to meet the philosophy of active learning instead of encouraging the learners to passively reproduce what has been memorised. Moreover, the process of PBL assessment must require the individual learners to analyse a problem, search for and then actively apply relevant information. Traditional education often uses product-oriented techniques to assess students' performance whilst the assessment used in PBL is more process-oriented.

According to Toulmin (1972), however, process-oriented objectives can be difficult to articulate, though they comprise the "hidden curriculum" of most courses. These objectives are those that relate to how practitioners of a discipline or profession think about and solve problems within a certain field. The content-oriented objectives are usually emphasised. In problem-based learning practitioners may struggle with defining, highlighting to learners, and then assessing process-oriented objectives. However, those who have researched the process-oriented outcomes of problem-based learning have found good results (Hmelo et al., 1997). Gallagher (1997) claims that assessments used in problem-based learning should be authentic. This means that the assessments should be structured in order that the learners can show their comprehension of the learning problems and their solutions in contextually-meaningful ways. The feedback the learners receive from their peers is also a critical part of assessment in problem-based learning. Furthermore, the learners can be assessed by their group members using a numerical scale based on "attendance, preparation for class, listening and communication skills, ability to bring new and relevant information to the group, and ability to support and improve the functioning of the group as a whole" (Allen et al., 1996, p.49).

Bridges and Hallinger (1996) also assert that the peer assessment should be part of students' final grades. In addition, the facilitator should supply detailed comments about each group member's strengths and weaknesses. Learners' self-evaluation can be a useful way to assess their own performance. It can be seen that peer assessment can be one of the effective strategies to engage students in their learning activities for a better group work result. This also helps students know their own contribution in relation to the outcomes of the whole group. As PBL assessment is process-oriented it needs to be continuously conducted during the learning process, based on various criteria such as individual contribution, group and class participation, individuals' self-assessment and group assessment, attendance and group presentation of tentative solutions to the problem. The greater the range of assessment processes used, the more possibilities there will be for the teacher to specifically support and assess the student learning.

2.2.3 Models of PBL

The classic model of PBL, according to Barrows and Tamblyn (1980), comprised the following steps:

- Students identified a complex real-world problem that was supposed to have no right or wrong answer.
- Students confronted the problem in small groups through discussions, which led to gap identification and development of viable solutions to resolve the problem.

• Students had an opportunity to conduct self-directed learning where they used information from different sources as they confronted the problem.
• Instructors provided guidance as students worked on their problems. Although different models have been proposed for PBL, in all these models the centre is the problem (Pease & Kuhn, 2010; Hmelo-Silver, 2004). This implies that the focus of the different forms of PBL is solving an ill-structured problem. This problem can be addressed in cooperative learning groups (Hmelo-Silver, 2004) or at the individual level (Pease & Kuhn, 2010). Conway and Little (2000) suggest that PBL can assume two different forms: as an instructional strategy or as a curriculum design. As an instructional strategy, PBL can be incorporated into an existing program as a teaching method for one topic, module, or component of a program. Others classify PBL into two categories: the pure model and the hybrid model (Brinkley, 2011).

The pure model utilizes PBL throughout the instructional process while the hybrid model mixes PBL activities with other teaching approaches such as lectures and tutorials. Currently, most programs are implementing the hybrid PBL because it does not require a comprehensive change to the whole curriculum and therefore is easier to incorporate (Brinkley, 2011; Degraffs & Kolmos, 2007). Pure PBL is not generally appropriate for all situations due to a number of factors. These factors relate to class size, number of facilitators, and curriculum designs.

Regardless of the model used, however, there is a general agreement that a successful PBL instruction must have the following steps:

The problem: The instructor presents a problem or scenario to the students.

(Duch, 2001; Hmelo & Ferrari, 1997). The students read through the problem to understand what they are seeking. Discussion of the problem: confronted with the problem, students determine what they already know about the problem and what information is missing and needs to be researched. Once students establish what is known and unknown, they create their learning goals and determine how to proceed (Belt et al., 2002; Hung et al., 2008).

Research: Most PBL groups share responsibilities amongst individual members. One way is to give each student a specific objective to do research on or to let all students study the same objective independent of each other. This ensures that everyone is fully involved in the activities. Sometimes groups ask each individual to investigate similar pertinent issues within a single group and divide non-pertinent issues amongst individuals in the group. Students then embark on their respective self-directed investigations. These typically start with literature review through reading journals, books, websites (Belt et al., 2002; Hung et al., 2008). Sometimes they visit experts, or use other resources to collect information (Hung et al., 2008).

Results analysis: Whether in groups (Belt et al; 2002; Hung et al; 2008) or as individuals (Pease & Kuhn, 2010), students analyse their results. Whenever necessary, students rewrite or refine their methodology and embark on further research to buttress their initial findings. This continues until satisfactory results are obtained. How long students repeat the data collection process depends on the complexity of the problem, time, and other factors. This enables students to apply newly acquired knowledge through the discussions to their investigations (Hung et al., 2008).

Solution generation, presentation, and evaluation: During the results group analysis phase, students generate solutions to their problem. To make more accurate generalizations, they sometimes rely on what is already in the literature and other research materials. Once they get their solutions, they make a written report or an oral presentation to make their solution public (Hmelo-Silver, 2004).

Fig 2 shows the general steps for the successful implementation of problem based learning.

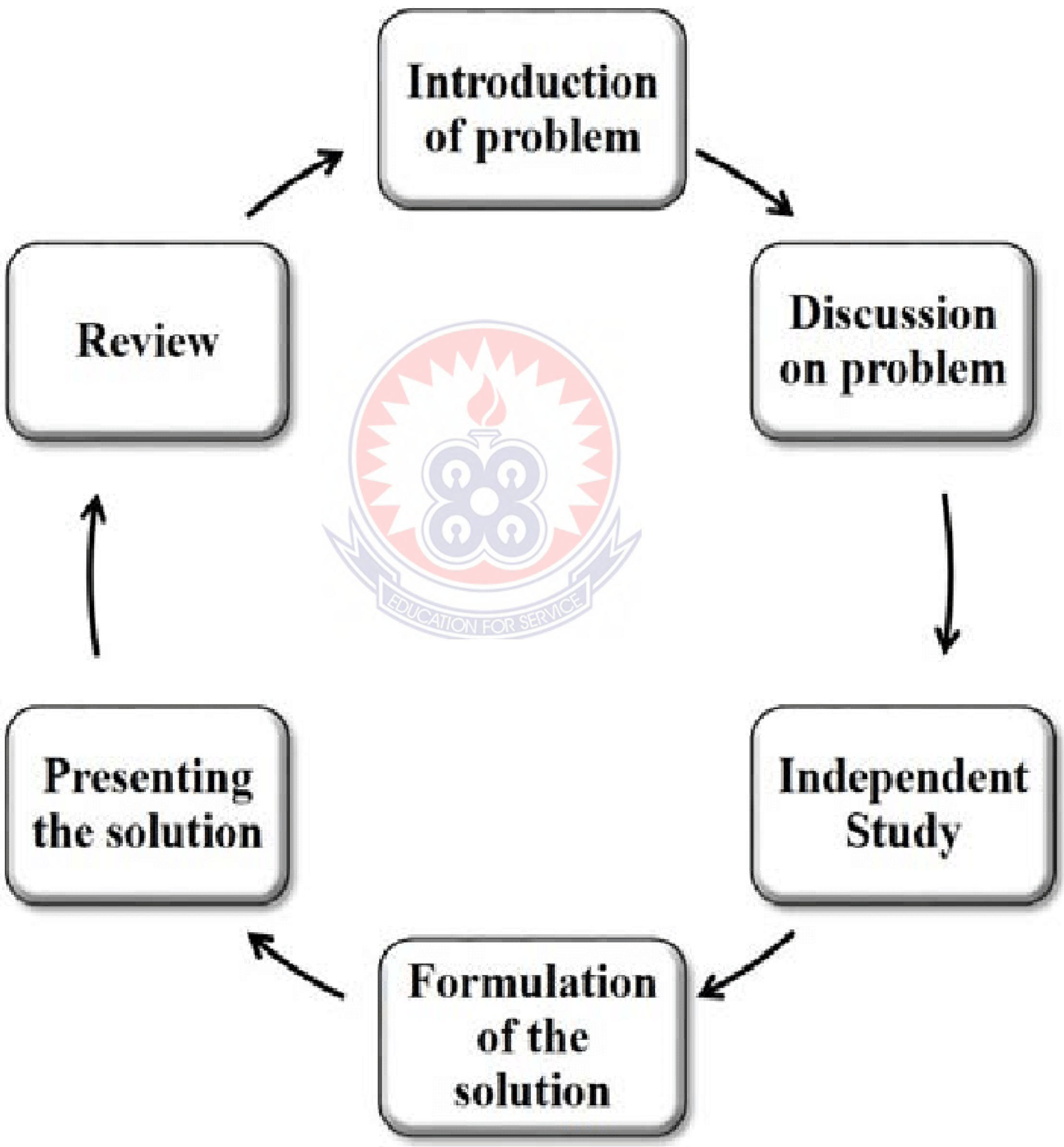


Figure 2: Steps for the Implementation of Problem-based Learning.

2.2.4 Advantages of PBL

Promotes deep learning

PBL replaces traditional lectures with facultative mentoring, assistive learning, discussions, and real-life experiences. This helps in promoting deep learning within the individuals. Thus, students' knowledge also grows as more and more discussions are made.

Develops retention of knowledge in the long term

PBL activities can improve their information retention and recalling ability at one and the same time. The sharing of facts and ideas during class discussions can enhance its subsequent retrieval, thereby, making it easier for kids to remember them.

Introduction to open-ended questions

Most of the problems introduced in PBL curriculum are open-ended question. These give room for more and more discussions, data retrieval, and more and more understanding of the subject matter.

Improves teamwork and interpersonal skill

Successful completion of PBL challenges hinges firmly on communication and interaction. Meaning, instead of memorizing facts on their own, students get a chance to present them in front of a group, defending and revising them when required. This helps a lot in building transferable skills based on teamwork and collaboration.

Opportunity to apply skills in the real world

PBL can help students develop skills that they can apply in real-world scenarios. The tangible context of the subject matter presented in PBL activities can make the entire learning experience more durable and profound in the long term.

2.2.5 Disadvantages of PBL

Requires a lot of time and effort for implementation

Good PBL curriculum implementations require a huge amount of time and work on the teachers' end. It also requires constant monitoring and recording of the performance of the student(s) throughout the process.

Poor performance in theoretical tests

Devoting too much time in PBL activities can create issues when students appear for standardized tests. This is because they may not have the right breadth of knowledge to achieve high scores in such examination.

Integration of multiple disciplines

To make the PBL model a success, multiple disciplines have to be integrated so students can understand the different aspects of a situation. Hence, systematic organization and extensive research are required for proper PBL implementation.

Varying degrees of applicability and relevancy

It can be exceptionally difficult to identify a problem that can be tangible enough for students to solve in relevance to the content of their studies. This automatically introduces two issues. One, it's easy for students to get distracted from the challenges presented by the problem, they may miss out on pertinent information. Two, you can swerve off the focus and the purpose of the problem to make students run into abrupt obstacles. Overcoming them may have its benefits, but it can also compromise the initial planning which you did at the beginning of your lessons.

2.3 The Mole Concept

According to Jensen (2004) the idea of the mole dated back to 1900 when it was first introduced by Wilhelm Ostwald in an attempt to provide an alternative to the explanation of the laws governing stoichiometry. The word “mole” was derived from the Latin word moles meaning a ‘heap’ or ‘pile. The mole, also spelled mol, in chemistry, is a standard scientific unit for measuring large quantities of very small entities such as atoms, molecules, monoatomic/polyatomic ions, and electrons. The mole designates an extremely large number of units, $6.02214076 \times 10^{23}$. The General Conference on Weights and Measures defined the mole as this number for the International System of Units (SI) effective from May 20, 2019. The mole was previously defined as the number of atoms determined experimentally to be found in 12 grams of carbon-12. The number of units in a mole also bears the name Avogadro’s number, or Avogadro’s constant, in honour of the Italian physicist Amedeo Avogadro. Avogadro proposed that equal volumes of gases under the same conditions contain the same number of molecules, a hypothesis that proved useful in determining atomic and molecular weights and which led to the concept of the mole. The 'mole concept' in Chemistry deals with (1) the concept of number of moles, (2) the relationship between 'mole' and other physical quantities, and (3) the quantitative relationship among particles taking place in chemical reactions.

The number of atoms or other particles in a mole is the same for all substances. The mole is related to the mass of an element in the following way: one mole of carbon-12 atoms has $6.02214076 \times 10^{23}$ atoms and a mass of 12 grams. In comparison, one mole of oxygen consists, by definition, of the same number of atoms as carbon-12, but it has a mass of 15.999 grams. Oxygen, therefore, has a greater mass than carbon. This reasoning also can be applied to molecular or formula weights. The concept of the mole helps to put quantitative information about what happens in a chemical equation on a macroscopic level. For example, in the chemical reaction $2H_2O \rightarrow O_2 + 2H_2$, two moles of water are decomposed into two moles of molecular hydrogen and one mole of molecular oxygen. The mole can be used to determine the simplest formula of a compound and to calculate the quantities involved in chemical reactions. When dealing with reactions that take place in solutions, the related concept of molarity is useful. Molarity (*M*) is defined as the number of moles of a solute in a litre of solution.

The mole concept in Chemistry is a quantitative unit that provides a description of the amount of substances reacting together, and the amount of their corresponding products in a reaction medium. An understanding of the mole concept is pre-requisite to the understanding of many topics in School Certificate and Advanced Level Chemistry. It is also crucial to the ability of students in solving stoichiometric problems in Chemistry (Dori & Hameiri, 1998). The mole concept is a convenient method of expressing the amount of a substance. Any measurement can be broken down into two parts – the numerical magnitude and the units that the magnitude is expressed in. For example, when the mass of a ball is measured to be 2 kilograms, the magnitude is '2' and the unit is 'kilogram'. When dealing with particles at an atomic (or molecular) level, even one gram of a pure element is known to contain a huge number of atoms. This is where the mole concept is widely used.

The mole is very important in chemistry because it represents the link between the microscopic and the macroscopic, especially in terms of mass. *A mole of a substance has the same mass in grams as one unit (atom or molecules) has in atomic mass units*. The mole unit allows us to express amounts of atoms and molecules in visible amounts that we can understand. For example, we already know that, by definition, a mole of carbon has a mass of exactly 12 g. This means that exactly 12 g of C has 6.022×10^{23} atoms:12 g C = 6.022×10^{23} atoms C.

We can use this equality as a conversion factor between the number of atoms of carbon and the number of grams of carbon. How many grams are there, say, in 1.50 × 10^{25} atoms of carbon? This is a one-step conversion:

$$1.50 \times 10^{25} \text{ atoms C} \times \frac{12.0000 \text{ g C}}{6.022 \times 10^{23} \text{ atoms C}} = 299 \text{ g C}$$

In the field of chemistry, a mole is defined as the amount of a substance that contains exactly 6.02214076 * 10^{23} 'elementary entities' of the given substance. For example, one mole of a pure carbon-12 (^{12}C) sample will have a mass of exactly 12 grams and will contain 6.02214076*10^{23} (N_A) number of ^{12}C atoms.

The relationship between mole, molar mass, mass, Avogadro's constant as well as the number of entities is displayed in figure 3 below.

The following are some of the Quantities related to Mole Concept and their Formulae

Atomic and Molecular Mass

The atomic mass of an element is the mass of one atom of the element expressed in atomic mass units (amu). It accounts for the abundance of the various isotopes of the element and assigns an average value to the mass of one atom of the element. For example, the atomic mass of carbon is 12.011 atomic mass units since carbon samples generally contain 98.89% of the carbon-12 isotope, 1.11% of carbon-13, and trace amounts of carbon-14. However, the atomic masses of these isotopes are different. The atomic mass of a carbon-12 atom is 12 atomic mass units, but that of a carbon-13 atom is 13 amu. The atomic mass of an element is roughly equal to the sum of all the protons and neutrons present in its nucleus.

The molecular mass of an element is the sum of the atomic masses of all its constituent elements. This quantity is also represented in terms of atomic mass units. Therefore, the molecular mass of water is equal to the sum of the atomic masses of its constituents – hydrogen and oxygen. The atomic mass of hydrogen is 1.00794 amu and that of oxygen is 15.9994. Since water molecules contain 2 hydrogen atoms and only one oxygen atom, the molecular mass of H_2O is 18.0154 amu.

Molar Mass

The molar mass of a substance is defined as the total mass of one mole of the substance. It is often represented in terms of 'grams per mole' (g/mol). However, the SI unit of this quantity is kg/mol. Molar mass can be represented by the following formula:

Molar mass of a Substance = (Mass of the Substance in grams)/ (Number of Moles)

For example, the molar mass of water is approximately 18.015 g/mol, which is the mass of N_A number of water molecules.

Gram Atomic Mass and Gram Molecular Mass

The gram atomic mass of an element is the mass of one mole of that element. Similarly, the gram molecular mass of a compound refers to the mass of a single mole of the compound. Therefore, the gram atomic mass of hydrogen is approximately 1.007g and the gram molecular mass of water is approximately 18.015g.

The number of moles in a given sample of an element/compound can be calculated by dividing the total mass of the sample by the molar mass of the element/compound, as described by the following formula.

Number of Moles = (Mass of the Sample)/ (Molar Mass)

The total number of atoms/molecules in a sample can be calculated by multiplying the number of moles with the Avogadro constant. This formula can be written as:

Number of Atoms or Molecules = (Number of Moles) $*(6.022*10^{23})$

The relationship between the atomic mass unit (amu) and the gram is given by:

1 amu = (1gram)/ $(6.022*10^{23}) = 1.66*10^{-24}$ *grams*

Therefore, the mass of one mole of an element will be equal to its atomic mass in grams.

Number of Electrons in a Mole of Hydrogen Molecule

The number of electrons in a mole of hydrogen molecule is

1 mole of H_2 contains 6.023×10^{23} molecules and each molecule of H_2 contains two electrons.

1 mole = 6.023×10^{23}

Therefore, the total no. of electrons in one mole of H_2 *are* 12.046×10^{23}. *The Relationship of the mole to the mass and molar mass, the number of particles and the Avogadro's constant, the volume and the molar volume.*

2.4. Action Research

Action research was introduced by social psychologist, Kurt Lewin in his paper, "Action Research and Minority Problems," published when he was a professor at MIT. He described action research as comparative research on the conditions and effects of various forms of social action and research leading to social action that uses a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action (Mapotse,2017). Action research happens when people research their own practice in order to improve it and to come to a better understanding of their practice situation "It is action because they act within the systems that they are trying to improve and understand. It is research because it is systematic, critical inquiry made public" (Feldman, 2002, p. 240). Feldman explains that action research can help to develop a professional community, illuminate the power of relationships in educational situations, and help one recognize their own expertise.

Parsons and Brown (2002) define action research as a form of investigation designed For use by teachers to attempt to solve problems and improve professional practices in their own classrooms. It involves systematic observations and data collection which can be then used by the practitioner-researcher in reflection, decision-making and the development of more effective classroom strategies. Action research is a natural part of teaching because teachers are continually observing students, collecting data and changing practices to improve student learning and the classroom and school environment. Action research provides a framework that guides the energies of teachers toward a better understanding of why, when, and how students become better learners (Miller, 2007). According to Brody (2006) action research is the reflexive process by which educators systematically study their problems in order to guide, correct and evaluate their decisions and actions regarding the improvement of teaching and learning in their individual professional context. Action research is a collaborative, cyclical process of: strategic planning, action, implementing the plan and observation, evaluation and self-evaluation, critical and self-critical reflection on the results and change in social, cultural and political systems.

2.4.1 Types of action research in educational settings

Mills (2003) defines action research as any systematic inquiry conducted by teacher researchers to gather information about the ways that their particular school operates, how they teach, and how well their students learn". The information is gathered with the goals of gaining insight, developing reflective practice, effecting positive changes in the school environment and on educational practices in general, and improving student outcomes.

There are a variety of action research methods available to use in educational settings. the method that a researcher chooses will depend on the group and the goals that are identified. It can involve a single teacher investigating an issue in his or her classroom, a group of teachers working on a common problem, a team of teachers working with others focusing on a school, or an even larger group working on a district-wide issue. Ferannce (2000) classifies these different types of action research as follows:

- Individual teacher research usually focuses on a single issue in the classroom.

The teacher may be seeking solutions to problems of classroom management, instructional strategies, use of materials, or student learning. The problem is one that the teacher believes is evident in his or her classroom and that can be addressed on an individual basis. The research may be such that the teacher collects data or might look at student participation. One of the drawbacks of individual research is that it may not be shared with others unless the teacher chooses to present his or her findings at a faculty meeting, a presentation at a conference, or by submitting written material to a journal. It is possible for several teachers to be working concurrently on the same problem with no knowledge of each other's work.

- Collaborative action research may include as few as two teachers or a group of several teachers, along with others interested in addressing a classroom, a department, or school-wide issue. This issue may involve one classroom or a common problem shared by many classes. Teachers may have support from individuals outside of the school, such as a university or community partner.

- School-wide research focuses on issues common to everyone in the school. For example, a school may have a concern about the lack of parental involvement in activities and is looking for a way to reach more parents to involve them in meaningful ways. Or the school may want to address its organizational and decision-making process. Teams from the school staff, work together to narrow the question, gather and analyse the data, and decide on a plan of action. An example of action research for a school might be to examine its state test scores to identify areas that need improvement and to determine a plan of action to enhance student performance. Teamwork and individual contributions to the goal are very important in this form of action research. Problems can easily arise as the team tries to develop a process and make commitments to each other. Though challenging, there is a sense of ownership and accomplishment in the results that come from a school-wide effort.

- District-wide research is more complex, utilizes more resources, and is shared by more people. Issues can be organizational, community-based, performance-based, or focused on decision-making processes. A district may choose to address a problem common to several schools or to examine a problem of organizational management. Potential disadvantages are the amount of documentation and communication required to keep everyone in the loop and the work involved to keep the process in motion. Collecting data from all participants requires a commitment from the staff to do their fair share responsibilities and to meet agreed-upon deadlines for assignments.

An advantage is school reform and change built upon common understanding and inquiry. The involvement of multiple groups can provide fuel for the process and create an environment of interested and motivated members as well.

2.4.2 Models of action research

Various models or working definitions of action research exist in literature. However, all of them capture the same concept, some have more steps and articulate them more fully, but the essence of learning through action, gathering data, reflecting on the outcomes, and reworking as needed exist throughout. A few models for conducting action research are presented below:

Model 1

Identify the problem - find the general or initial idea. Evaluate the problem - observe, survey, investigate the problem. Make a recommendation – make a plan. Practice the recommendation – take the first action step, try it out. Reflect on the practice - evaluate the recommended practice or action step. Re-evaluate if needed - modify the plan, take a second action step if needed i.e., another iteration (Gorski, 2006).

Model 2

Plan - Act - Observe - Reflect. This comes from Kemmis and McTaggart (1988).

Model 3

Look - Build a picture and gather information. Define and describe the problem to be investigated and the context in which it is set. Describe what all the participants (educators, students, faculty, etc) have been doing.

Think - Interpret and explain. Analyse and clarify the situation. Reflect on what the participants have been doing. Look at areas of success and any deficiencies, issues or problems.

Act - Resolve issues and problems. Judge the worth, effectiveness, appropriateness, and outcomes of the activities. Act to formulate solutions to any problems. Repeat the cycle as needed (Stringer, 1999).

2.4.3 Difference between action research and other types of research

Action research differs from other types of research in at least four ways. First, it embeds the researcher into the practices of the people involved. The teacher-researcher is inclined to learn more and be more willing to apply what he or she learns, when they do something themselves. Thus, action research has a good chance of changing teacher practice. Second, action research has a social dimension often not seen in other forms of research. The research takes place in everyday situations and is aimed at improving everyday problems in the classroom or in the school. Third, the initiating researcher does not need to remain completely objective. They can openly acknowledge their biases to other participants. Fourth, this type of research is more likely to have lasting effects on the group involved because often the group is involved in the change that is taking place. Like behaviour modification, practice helps pave the way to a new method or assists in enabling the change that is desired.

Elliot (1994) argues that educational action research has some features not present in other forms of research: "It has a pedagogical aim which embodies an educational ideal and which all those participating is committed to realizing. It focuses on changing practice to make it more consistent with the pedagogical aim. It gathers evidence about the extent to which practice is consistent or inconsistent with the aim. In identifying inconsistencies between aspiration and practice, it problematises the assumptions and beliefs (theories) tacitly embodied in the latter. It involves teachers in a process of generating and testing new forms of action for realizing their aspirations, and thereby in reconstructing their practical pedagogical theories. It is a pedagogical process characterized by teacher reflexivity. From an action research perspective, teaching is a form of research and vice versa.

2.5 Influence of Perception and Attitude on Performance

According to Perreault and McCarthy (2005), perception is how we gather and interpret information from the world around us. Since we constantly gather and interpret information from our environment, it is accurate to say therefore that perception is a process and not an action. Hawkins et al. (2004) describe perception as exposure, attention and interpretation. This explanation of perception makes an attempt to reduce it to a three-step process with each step requiring a deliberate action. Jobber (2004) goes further in his own definition of the perceptual process by making an attempt to identify the important elements in the process. According to him, "perception is the complex process by which people select, organize and interpret sensory stimulation into a meaningful picture of the world."

Though the previous definitions that we have considered also highlighted the importance of the people who do the selection or gathering and interpretation of the information, Jobber's definition crystallizes the role played by the information itself which he described as the "external stimuli." By referring to the information gathered as stimuli, he emphasizes the role of the information as opposed to the passive role imposed on it by the other definitions. He also talked about creating picture of the world as a result of the interpretation of the sensory stimuli. Another scholar who also referred to the information gathered as sensory information was Santrock (2003). He defines perception as the process of organizing and interpreting sensory information to give meaning. Perception functions as means of representing information from the outside world internally. Hence, it is the personal creation of the particular individual who is involved in the process.

Eggen and Kauchak (2001) gave cognitive dimension of perception; they see perception as the process by which people attach meaning to experiences. They explained that after people attend to certain stimuli in their sensory memories, processing continues with perception. Perception is critical because it influences the information that enters working memory. Many kinds of research have found out that positive perceptions held by students have a positive impact on students' performance. Research on science education in the past has focused primarily on cognitive educational outcomes. However, research into the affective domain has now become a major focus in science education, and one of the key variables within the affective domain that has drawn attention is attitude (Weinburgh, 1995). Students' own attitude is also another factor that affects their performance in their study of chemistry. In chemistry education, attitude is an important factor that affects students' achievement. Students with positive attitudes towards science are successful in the classroom as they are able to form sound concepts and thereby perform better academically (Koballa & Glynn, 2007).

The word attitude, which comes from the Latin word "Optus" meaning suitability or adaptation, means behaviour, state, and line of conduct. Kartubi (2017) mentioned that there exist different definitions of the term "Attitude", which is characterized as learned tendencies that prompt an individual to exhibit certain behaviours in front of certain people, times and situations. In addition, Ünal and Işeri (2012) said attitude is the state of emotional and mental preparation, which is formed through experiences, that has a directive or dynamic influential power on an individual's behaviours towards all things and situations. Ricards and Schimidth (2003) as cited by Noviani (2020) mentions that attitudes are the opinions and feelings that one usually has about something or someone and they can be positive or negative. Sawyer et al. (2001) defined attitude as a disposition or tendency to respond positive or negative toward certain things (idea, object, person, situation and so forth). An attitude concerning a class of objects is the meaning that class has for the person, with a stress on how the individual evaluates the class, whether positively or negatively.

The characteristics of attitude as summarized by Goldstein cited in (Abdalla, 1991) are as follows:

(i) Attitudes are learned

(ii) Attitudes predict behaviour

(iii) The social influences of others affect attitudes

(iv) Attitudes are evaluative, emotion is involved.

Festus (2007), contend that performance appears generally to be the fundamental goal behind every life struggle, but the positive platform has consequential effects of improving the worth of the student and can only be achieved through acquisition of positive learning attitudes. The attitudes of a student trigger his behaviour. Attitudes are antecedents which serve as inputs or stimuli that trigger actions. Attitudes can distort the reception and perception of information and affect the degree of their retention. The meaning of attitude focused on, in this review of the literature, centred on affective reactions to mole concept. Attitude in this context implies interest, enthusiasm, satisfaction, enjoyment, feelings of like and dislike.

2.6 Concept and Sources of Misconception among Students

Concepts are ideas, notions or thoughts which can be regarded as the emerging image of the mental process (Lakpini, 2006). It may be a product of some intuitive re-appraisal. The only problem is that a concept could be concrete, abstract or even blurred. Adamu (2011) defined concepts as a summary of the essential characteristics of a group of ideas.

Misconception might also be referred to as preconceived notions, non-scientific beliefs, naïve theories, mixed conceptions or conceptual misunderstandings. Basically, in science, there are instances where the ideas in the mind of individuals may be different from what is scientifically correct (Sani, 2010). What is of great concern about misconceptions is that individuals continue to build knowledge on their current understanding which may have negative impact on future learning.

The study of misconceptions has generated considerable interest among science educators such as it is essential for a successful teaching and learning interplay. Various authorities have different views on what misconception is. For instance, Watson and Kopnicek (1990) described misconceptions as personal constructions, which are formed on what an individual feels or sees. These experiences have profound effect on the learner's willingness and ability to accept other more scientifically grounded explanations of how the world works. They opined also that misconceptions are erroneous beliefs or alternative views of scientific principles or wrong notions about certain scientific concepts. Chiu (2005) agreed that students do not grasp fundamental ideas covered in classroom teaching instructions. Even some of the best students give the right answers but only using correctly memorized words.

When questioned more closely, these students reveal their failure to understand fully the underlying concepts.

Many studies have shown that students develop their scientific misconceptions from many sources (Dikmenli & Cardak, 2008; Soyibo, 2008; Sani, 2010). Those sources have always created inconsistent frameworks or incorrect representation of the scientific concepts. The sources include but not limited to personal experiences (such as observation), gender, peer interaction, media, language, symbolic representation, textbooks, laboratory works, environmental, social, religion among others (Adamu, 2011). A number of researchers also revealed that students at different ages held similar misconceptions that influence their understanding of more complex concepts (Lee, 2004; Gonen & Kocakaya, 2010). Deshmukh (2009), posits that language 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. Hwang (2004) found that not only students of secondary schools have misconception in identifying whether a substance is an acid or a base, but their teachers had misconception as well. Voska and Heikkinen (2000) in their study noted that even college students did not understand or misconceive how adding a solid to the solution influences the equilibrium state. Students' aversion to certain key concepts in chemistry is on the increase. Such concept includes hybridization, chain reaction, mole concept, chemical equation, polymerization and even nomenclature of organic compounds.

Prominent among the factors that have been identified to be responsible for these misconceptions are poor method of instruction, improper exposure to laboratory activities, lack of organizational skills and inadequate exposure to problem solving procedures among others (Sani, 2010). Information processing strategies play a vital role in shaping learning outcomes, because they influence new stimuli and the subsequent generation of meaning. As learning is a personal construct, there is likelihood that some constructions will be erroneous and consequently may adversely affect subsequent learning. Identification of these misconceptions will be a first step in trying to look for a way to remedy them. A student who has a partial understanding of a concept or misconception will likely resort to rote learning. In contrast, a student who properly understands the concept would approach the problem requiring solution in his own way and may be able to tackle most puzzles correctly.

The mole concept's abstract nature creates learning difficulties and misconceptions among students. For instance, the SI defines a "mole" as the amount of substance containing the same number of entities as there are in exactly 12 grams of carbon-12 atoms (Wieser, 2006). This term causes some confusion among the students since the numerical value (12) of the mass of the carbon atom looks identical to the value of its molar mass. They tend to assume that both values have the same meaning (Dahsah & Coll, 2007). Students in secondary school normally think of the number of moles of a substance in terms of mass. Most of them identified the mole with Avogadro's number (61%) and with mass (25%). Only 11% of educators, according to Tullberg, Stromdal, and Lybeck (1994), as cited by Beong (2016), recognized the mole as the unit of "amount of substance. "Avogadro's number (61%) and mass (25%) were used by the majority of them to identify the mole.

Again, students only used the term "mole" to refer to molecules when it actually applied to all entities, including ions and electrons. The mole was perceived by students to be a certain mass, a specific number of gas particles, or a characteristic of molecules (Indriyanti, 2017).

2.7 Traditional Teaching Methods in Science Classrooms (Traditional Instruction)

In Ghanaian schools and colleges, most often chemistry is usually taught by the traditional didactic approach in which teachers deliver formal lectures to students. Traditional instruction is teacher – centred and characterized by direct instruction (Kinney & Robertson, 2003). According to Kinney and Robertson, direct instruction usually includes the presentation of material, thinking aloud by the teacher, guided practice, correction and feedback and modelling by the teacher. The teacher plays the role of the expert imparting knowledge and decides what, when and how students should learn with all students studying the same topic at the same time (Brown, 2003). All students are different because each has a unique experience of the world. Giving the same piece of information to all students at the same time may only work for those whose schema can assimilate it (King, 2004). Not all students are at the same level of understanding at the same time. This kind of teaching approach mostly leads to a surface level learning and an over-dependence on the teachers.

According to a survey, in a traditional course, students only listen, and they can only retain 26% of the knowledge the teacher presents (King, 2004). Students learn passively and employ surface level processing. They are over-dependent on information selected and provided for them by their lecturers, research from a number of disciplines suggests that oral presentations to large groups of passive students contribute very little to real learning (McDermott & Shaffer, 1992). In college and universities, the predominant mode of instruction has been the presentation of material through lecture and demonstration using whiteboard, chalkboard, overhead, power point or graphing calculator (Armington, 2003). Teachers give formal lectures to transmit knowledge. Students receive it passively and are expected to reproduce it accurately in examinations. The teacher talks and students listen and write. The teacher demonstrates step by step procedures which are reinforced with drill and practice and interaction is limited to students responding to the teacher's questions.

Some educators have a very negative view of the traditional lecture. According to Brown (2003), the teacher is responsible for thinking and the students memorize and recite. Hence teachers are focused on content, schedules and standards, but not on the needs of the students. Felder and Brent (1996) describe the traditional lecture as stenography with the teacher reciting the course notes, the students transcribing the notes, and "the information not passing through anyone's brain. It encourages rote learning and memorization. Teachers that teach by lecturing operate under the assumption that if they do not lecture, they will lose control of the class; they view their students as empty pails waiting to be filled and themselves as the "sage on the stage" (Mahmood, 2006).

It has been found in most universities by many teachers and students that the conventional lecture approach in classroom is of limited effectiveness in both teaching and learning. In such a lecture students assume a purely passive role and their concentration fades off after 15 – 20 minutes (Oni, 2012). In such classroom situations, the teacher is the sender or the source of the information, the educational material is the information or message and the student is the receiver of the information as displayed in figure 3 This form of knowledge is termed as one-way flow of message, as depicted in figure 3.

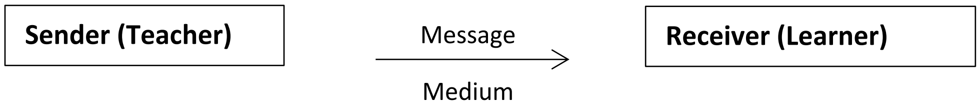


Figure 3: Mode of One-Way Message Channel

Despite the numerous disadvantages of the conventional methods, it has some advantages such as:

(i) More topics are covered in a relatively short period of time.

(ii) Students are given good training and insight into the techniques of analysing issues.

(iii) The method is very suitable for teaching very large classes.

(iv)It is very easy in using to deliver knowledge.

(v) Very few teachers are needed.

2.8 Modern Methods of Teaching in Science Classrooms

Effective teaching and learning in any subject at any institution are dependent on the instructional strategies used. This is a major factor responsible for the level of performance in any subject by the students. Learning difficulties can be solved to a great extent by using appropriate teaching methods. Different approaches can be adopted for instruction in order to induce, promote and direct learning. In western society, there are some new trends and changes in education including a movement from a ‘teacher-centred approach’ to a ‘student-centred approach’, and a recognition that, wherever possible, students must be active participants in the learning process in order to promote deep level processing of knowledge. (Hendry et al.,2001). These teaching strategies include student-centred learning, problem-based learning, conceptual change teaching, case studies, and cooperative learning.

A research study on student knowledge retention showed that students usually retain 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they see and hear; 70% of what they say; 90% of something they say while they are doing a task (Lagowski, 1990). So, the traditional approach to teaching science must be improved. Student-centred teaching is based on the hypothesis that students benefit by being given the freedom to study and search for solutions based on their personal interests (Hendry et al., 2001). Students are allowed to discuss and work together on the problem, to explore different paths for solutions without pressure in workshop tutorials. The responsibility for learning is with the students (King ,2004).

In order to overcome some shortcomings of traditional teaching approaches such as spoon-feeding and over-dependence on the lecturer, student-centred teaching is a useful method to improve traditional course teaching and adapt to the changes and trends in teaching theories and practice. The results of contemporary research in education theory have shown how students learn and how teachers teach students more effectively. This approach can give students flexibility, self-confidence and social skills. In student-centred teaching, the teacher teaches only what he or she considers important and difficult in the lecture. The responsibility of the teacher is not only to deliver skills and provide a conceptual map of the subject, but also to motivate students to be more active, adaptable, confident, creative, cooperative and inductive in their thinking. The teacher must help students to make the transition from passive listeners to active participants, changing from a superficial to a deep learning approach, developing the students' abilities and skills for lifelong learning. We should teach them 'fishing' not give them 'fish'. Students need to move from passive to active learning and from dependence to independence.

2.9 Gender and Performance

Academic achievement is the outcome of education, that is, the extent which a student teacher or institution has achieved their educational goals. Academic achievement is commonly measured by examination or continuous assessment but there is no general agreement on how it is best tested or which aspect is most important knowledge such as facts (Ward & Stoker, 1996). Individual differences have been linked to differences in intelligence and personality. Students with higher mental ability as demonstrated by IQ test and those who are higher in conscientiousness tend to achieve highly in academic setting (Ward & Stoker, 1996). The problem of students' under-performance in secondary schools has become an educational issue. In solving any problem however, it is pertinent to understand the causes of such problems. Many causes or agents have been studied as the etiological starting point for investigating the phenomena of school failure or success. These causes are looked into from several perspectives including the role of the students, teachers, parents or family, school environment, society, government etc. Notable works among these are effects of: students' study habits, school environment, teachers' competencies, parents' economic status, continuous assessment, educational funding etc.

Gender is one of such factors also mentioned in literature to have considerable effect on student's academic performances especially in science subjects. Gender is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the feminine and masculine (female and male) population (Adigun et al., 2015). The importance of examining performance in relation to gender is based primarily on the socio-cultural differences between girls and boys. Some vocations and professions have been regarded as men's (engineering, arts and crafts, agriculture etc.) while others as women's (catering, typing, nursing etc.). In fact, parents assign task like car washing, grass cutting, bulbs fixing, climbing ladders to fix or remove things etc. to the boys. On the other hand, chores like dishes washing, cooking, cleaning and so on are assigned to the girls (Abdul Raheem et al.,2017). In a nutshell, what are regarded as complex and difficult tasks are allocated to boys whereas girls are expected to handle the relatively easy and less demanding tasks. As a result of this way of thinking the larger society has tended to see females as a weaker sex.

Gender differences in achievement have been examined for some time, resulting in a substantial body of literature. Some of these researchers pointed out that there is no significant gender difference in students' academic achievement and retention in subjects while others found significant difference with either the boys or the girls performing better. So many factors contribute to the varied conclusions arrived at by all researches. Some of such factors include campaign for, understanding and implementation of gender equality in the study area. Another reason for the varied conclusion is the subject on which the gender equality is being measured on. Many studies have agreed with the observation that male students usually outperform female students in assessments particularly in the areas of mathematics and science. The analysis of a number of large assessments has demonstrated that male students generally performed better than did female students (Beller & Gafni, 2002). According to research, self-efficacy influences the choice and engagement in a task, the effort expended in performing it, and the standard of the performance (Bandura &

Schunk, 1981; Bandura, 1986; Hackett & Betz, 1989). Since its introduction, the concept of self-efficacy has gained increasing importance as a significant variable for the prediction of individual behaviour. Bandura (1997) states that gender and attitude influence academic performance to some extent through their mediating effects on self-efficacy beliefs.

2.10 Summary of the Reviewed Literature

It is impossible to overestimate the importance of learning theories in helping learners develop conceptual change because they frequently have significant effects on the teaching and learning process. To effectively use any teaching technique and promote effective learning, teachers must be aware of how it affects the students. Overall, teachers should understand that students build new understanding using what they already know and prior knowledge; as a result, the teaching and learning process should be student-centred rather than teacher-centred.

The use of PBL makes learners active in the learning process, it also enhances students' application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills (Hung, 2008). The goal of this research is to find more active and proactive ways to engage students than passive ones. The presentation of teaching materials by means of the PBL approach helps students to. process and develop information, to find alternative solutions, to take an active part in the learning process and to develop their problem-solving skills.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter looked at the study area, the research design, the population under study, the sample, the sampling techniques and the data collection instrument. The reliability and validity of the research instrument, the intervention as well as the data collection procedure and the mode of analysing the data are also addressed in this chapter.

3.1 Study Area

Obiri Yeboah Senior High School which is popularly known to the local people as Okumanin is located in a town called Assin Foso. The town is the district capital of the Assin Fosu Municipal in the Central region. The school is located in the northern suburb of the town on the Kumasi Road and has a total student population of about 1500.The Assin Foso Municipality shares common boundaries with Twifo Atti Morkwa District on the west, Assin South District on the south, Asikuma Odoben Brakwa District and Ajumako Enyan Esiam District on the east, Upper Denkyira East Municipal on the north-west and Adansi South District on the north.

3.2 Research Design

According to McCombes, (2019) a research design describes how a researcher will investigate the central problem of the research. This study used an in-class action research approach because its aim was to solve or improve upon a problem that affected a whole class. The field of education often uses action research, an interactive method of collecting information that's used to explore topics of teaching, curriculum development and student behaviour in the classroom (Mc Collister, 2014).

Action research is very popular in the field of education because there is always room for improvement when it comes to teaching and educating others. It is an approach to improve your own teaching practice. It begins with a problem encountered while teaching. The action researcher will go through a series of phases (reflect, plan, action, observe) called the Action Research Cycle to systematically tackle the problem. In practice, things rarely go perfectly according to plan first time round. Generally, you discover ways to improve your action plan in light of your experience and feedback from the students. One cycle of planning, acting, observing and reflecting, therefore usually leads to another, in which you incorporate improvements suggested by the initial cycle. Projects often do not fit neatly into a cycle of planning, action, observation and reflection. It is perfectly legitimate to follow a somewhat disjointed process if circumstances dictate (El Miedany, 2019).

There are different types of methods of teaching in the classroom, but action research works very well because the cyclic nature offers opportunity for continued reflection as it fosters deeper understanding of a situation with conceptualization and moves through several interventions and evaluation phases. Besides, it allows for professional growth and development of teachers. Meyer (2000) maintains that action research's strength lies in its focus on generating solutions to practical problems and its ability to empower practitioners, by getting them to engage with research and the subsequent development or implementation activities.

Fig 4 below describes the steps involved in the action research process.

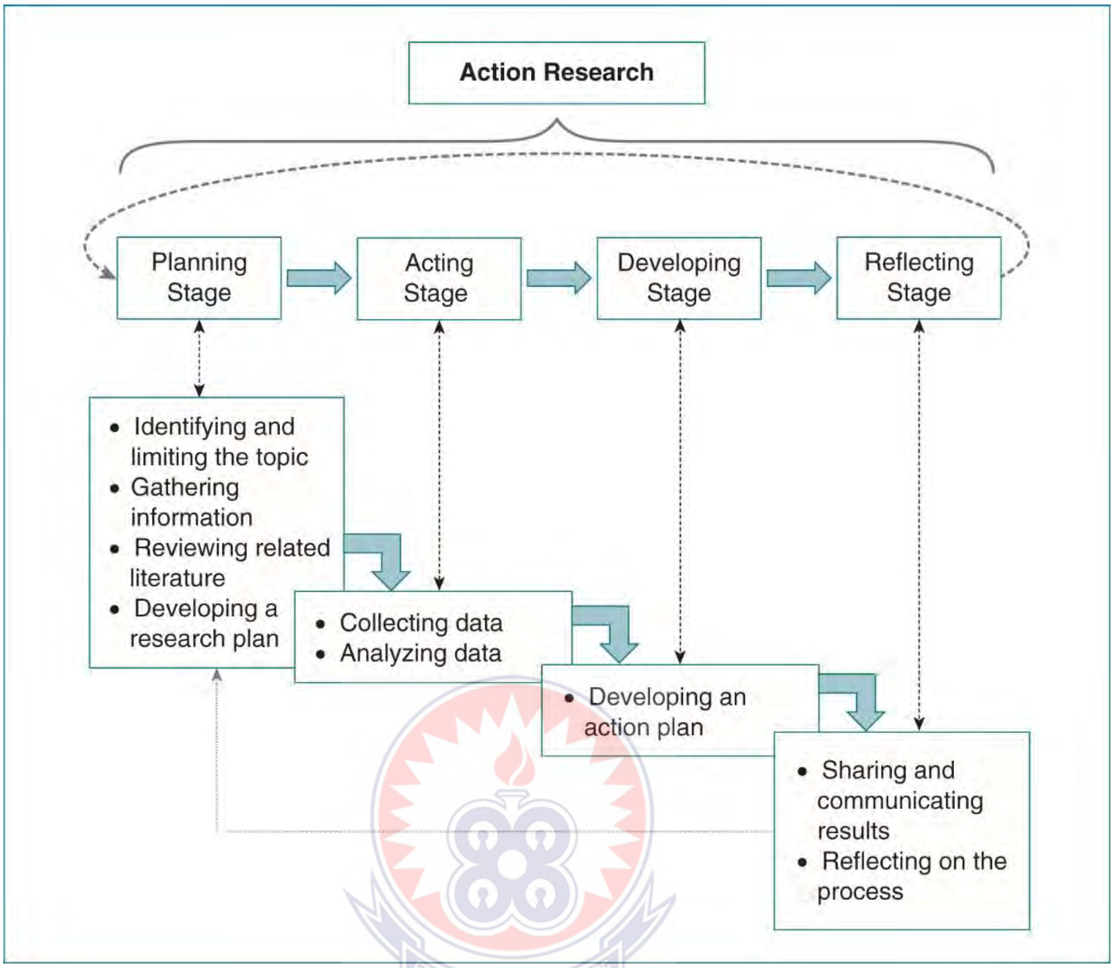


Figure 4: Action Research Process

3.3 Population

The target population for the study was all general science students in Obiri Yeboah Senior High School in the Assin North Municipality of the Central Region. The accessible population however was form 2 general science students. This school was chosen for the study because the researcher was more familiar with the area and students in the school.

3.4 Sample and Sampling Procedures

Sampling is a technique (procedure or device) employed by a researcher to

Systematically select a relatively smaller number of representative items or individuals (a subset) from a pre-defined population to serve as subjects (data source) for observation or experimentation as per objectives of his or her study (Sharma, 2017). The advantage of sampling is that the cost is lower, data collection is faster, and since the data is smaller it is possible to ensure homogeneity and to improve the accuracy and quality of the data. The procedure for selecting the respondents is very important in order to get vital data for the analysis of the work (Creswell, 2009).

For this study, a convenience sampling technique was used. Convenience sampling defines a process of data collection from a population that is close at hand and easily accessible to the researcher (Rahi, 2017). Thus, a sample population is selected because it is readily available and convenient. This technique was chosen because the students were easily accessible to the researcher since she is a teacher of the school and also knows the students' performance in chemistry. A sample is a subset containing the characteristics of a larger population. The sample for this study was thirty-nine (39) form two science students which comprised 17 girls and 22 boys.

The eligibility criteria specify the characteristics that people in the population must possess in order to be included in the study. The eligibility criteria in this study were that the students:

- were offering elective chemistry as a subject.
- in this class performed poorly on mole concept.
- were not writing WASSCE exams, so they were not under any tension.

- had experienced the traditional method of teaching chemistry at the SHS and would enjoy a new method of instruction.

3.5 Research Instruments

Tests (pre- and post-test) and questionnaire were used as the main instruments for collection of data for the study.

3.5.1 Tests items

A pre-test and post-test called the mole concept achievement test (MCAT) was conducted. The pre-test was to assess students 'understanding and measure their performance on mole concept before the intervention. A post-test with similar questions was also administered after the intervention so as to check effective improvement in students' performance. The test items for the pre and post-tests comprised of twenty (20) questions which was divided into two sections, A and B. Section A comprised of 15 multiple choice objective questions whilst Section B was made up of 5 essay questions. Most of the questions were selected from WAEC past questions and similar ones were also developed by the researcher. The test items centered on molar mass, molar volume, number of particles, number of moles and concentration of solutions. Both tests were marked and scored for 50 marks.

3.5.2 Questionnaire

A self developed questionnaire by the researcher was used to gather data on the perception and attitude of students towards the mole concept. It was categorized into *Pre* and *Post*. *Pre* refers to students' perception and attitude questionnaire (PREPAQ) towards the mole concept before the intervention and post refers to after the intervention (POSPAQ). This was done so as to determine any changes in conceptions, attitudes and perceptions by the new instructional method. McLeod (2018) states that a questionnaire is a research instrument consisting of a series of questions (or other types of prompts) for the purpose of gathering information from respondents. Questionnaires are cheap, offers assurance of anonymity and often have standardized answers that make it simple to compile data.

Likert scale is a rating system used in questionnaires that is designed to measure opinions, attitudes or behaviours. It consists of a statement or a question, followed by a series of five or seven answer statements. Respondents choose the option that best corresponds with how they feel about the statement or question (Bhandari & Nikolopoulou 2023). The questionnaire used in this study consisted of ten items which used a five-point Likert scale rating for collecting answers from respondents. The options included Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SDA) and Not Sure (NS). The respondents were to tick the appropriate option that applied in their case. Page-Bucci (2003) states that the Likert scale is the most widely used method of scaling in the social sciences today because they are much easier to construct and they tend to be more reliable than other scales with the same number of items. Likert scales also provide the researcher with opportunity to compute frequencies and percentages, as well as statistics such as the mean and standard deviation of scores.

3.6 Pilot-test

The researcher engaged the form 3 students of the school for a pilot test for the work. The essence of using a pilot test before the actual work was to ensure that the intervention and test items were valid and reliable.

3.7 Validity of the Instrument

Validity is the extent to which an instrument measures what it is supposed to measure and performs as it is designed to perform. The test items were prepared on the basis of the selected topic and then shown to some experienced chemistry teachers and the researcher's supervisor of this work for necessary suggestions to ensure its contents are valid.

3.8 Reliability

Creswell (2009) defines reliability as whether scores to items on an instrument are internally consistent, stable over time, and whether there is consistency in test administration and scoring. The majority of the objectives and essay questions were selected from WAEC past questions, this was to ensure that their appropriateness measures to the WAEC standard on mole concept. This approach is supported by Kirk and Millar (1999), who stated that reliability is the extent to which a test or procedure gives similar results under constant conditions on all occasions. The Cronbachs alpha was then used to calculate the coefficient of reliability to ensure that the instrument was very reliable. The reliability coefficient of the test items was calculated to be 0.78 which is in accordance with the findings of Ary et al. (2002) who stated that for test items instrument which measures intellectual achievement to be accepted, it should have Cronbach alpha Coefficient reliability of not less than 0.72.

3.9 Data Collection Procedure

According to Dudovskiy (2022) data collection is a process of collecting information from all the relevant sources to find answers to the research problem, test the hypothesis and evaluate the outcomes. The researcher sought permission and approval from the headmaster and the head of science department of the school to undertake the study. The research instruments were administered by the researcher personally to the students in their classroom and she explained the purpose of the study as well as the procedure and guidelines for filling the questionnaire and also assured them of anonymity and confidentiality. This was done to enable the researcher ensure that the questionnaire got to the respondents directly. It was also to explain further any part of the questionnaire that posed a problem to the respondents and also to ensure accuracy and 100 percent return rate of questionnaire.

Students Pre-perceptions and attitude towards mole concept questionnaire (PREPAQ) was administered to students first in order to avoid the influence of the chemistry achievement test on students' perception and attitude. A pre-test mole concept achievement test (MCAT) was then conducted after which students were taught using PBL model for four weeks. Students' Post-perception and attitude towards mole concept questionnaire (POSPAQ) and a post- test on mole concept achievement test (MCAT) was then administered after the intervention.

3.10 Implementation of the Intervention

The intervention was implemented in three phases namely: Pre-intervention phase, Intervention phase and Post intervention phase.

3.10.1 Pre-intervention phase

Students Pre-perception and attitude towards mole concept questionnaire (PREPAQ) was administered to students first to find out their perceptions and attitude towards the mole concept before the intervention. A pre-test was then conducted for the students in order to know their level of knowledge and performance in mole concept. The expected answers to the pre-test and samples of students' responses to the test are presented below.

3.10.2 Expected answers to pre-test (Questions in Appendix A) and samples of student answers.

SECTION B

1. **Expected Answer**

C of H_2SO_4 = 0.30 M,   m of H_2SO_4 = 1.35g

V of H_2SO_4 = ?

M(H_2SO_4) = 2x1 +32 +16x4 = 98 $gmol^{-1}$

$C=\frac{n}{V}$ but $n=\frac{m}{M}$ $C=\frac{m}{MV}$ $V=\frac{m}{MC}$

$V=\frac{1.35}{98 \, x \, 0.3}$

V=0.046 dm^3 = 46.0 cm^3

Or

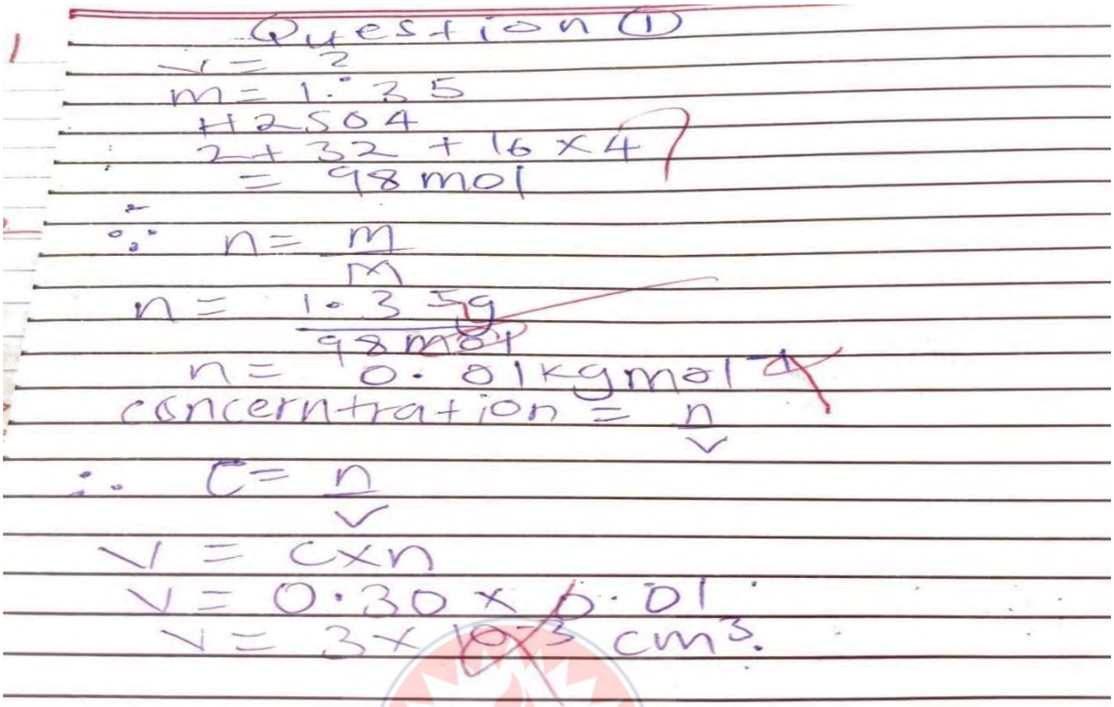
n(H_2SO_4) = $\frac{m}{M}$ = $\frac{1.35}{98}$ = 0.0138 mols

$C=\frac{n}{V}$ $V=\frac{n}{C}$ $V=\frac{0.0138}{0.30}$ V = 0.046 dm^3

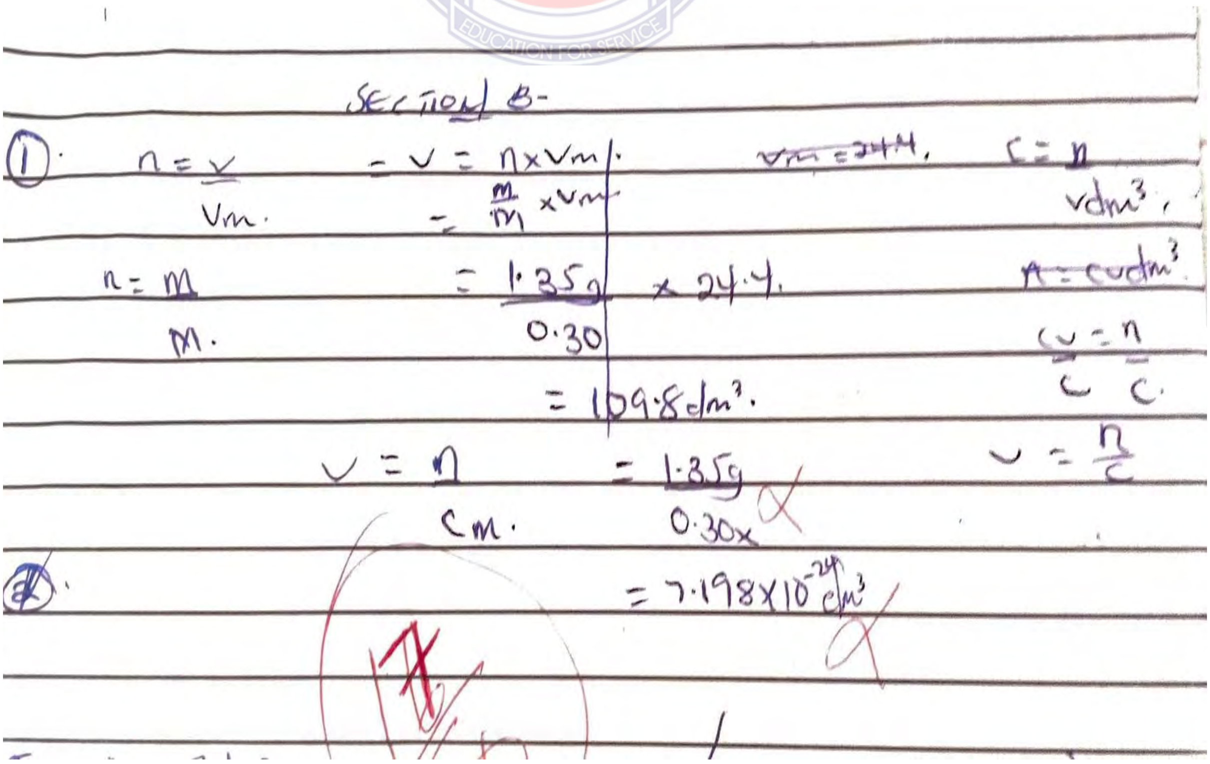
Where C is amount concentration, n is number of moles, V is volume, m is mass, M is molar mass.

Student Responses

Answer by Student 1



Answer by Student 2



2. **Expected Answer**

mass of aspirin = 0.25g, volume of solution = 100 cm^3

(mols)n =? N= (number of molecules) =?

L(Avogadro's constant) = $6.02x10^{23}$

$M(C_9H_8O_4)$ =12x9 +8x1 +16x 4=180 $gmol^-$

Mols (n) of aspirin in 100 cm^3 $=\frac{m}{M} = \frac{0.25}{180}$

Mols (n) of aspirin in 100 cm^3 = 0.00139 mol

0.00139=100

Mols of aspirin in 1.0 dm^3= 0.00139x $\frac{1000}{100}$

=0.0139 mol

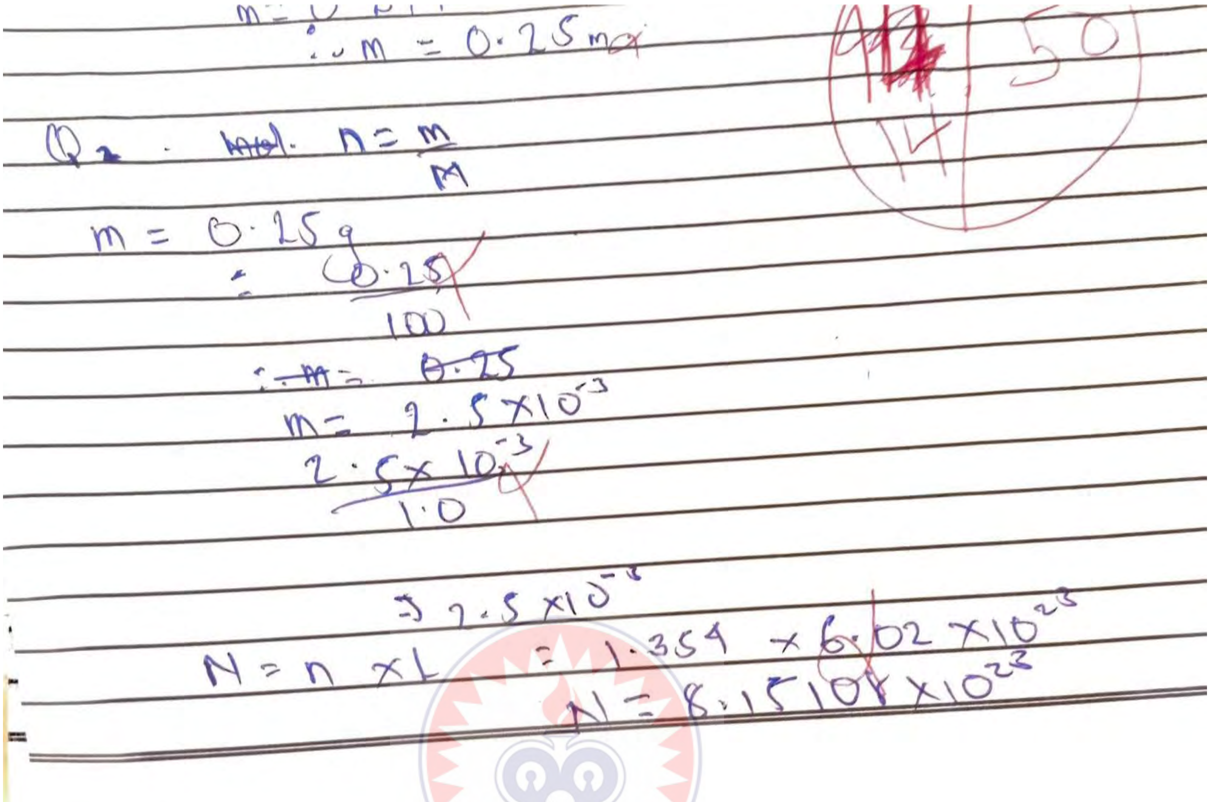
N = nL

= 0.0139 x $6.02x10^{23}$

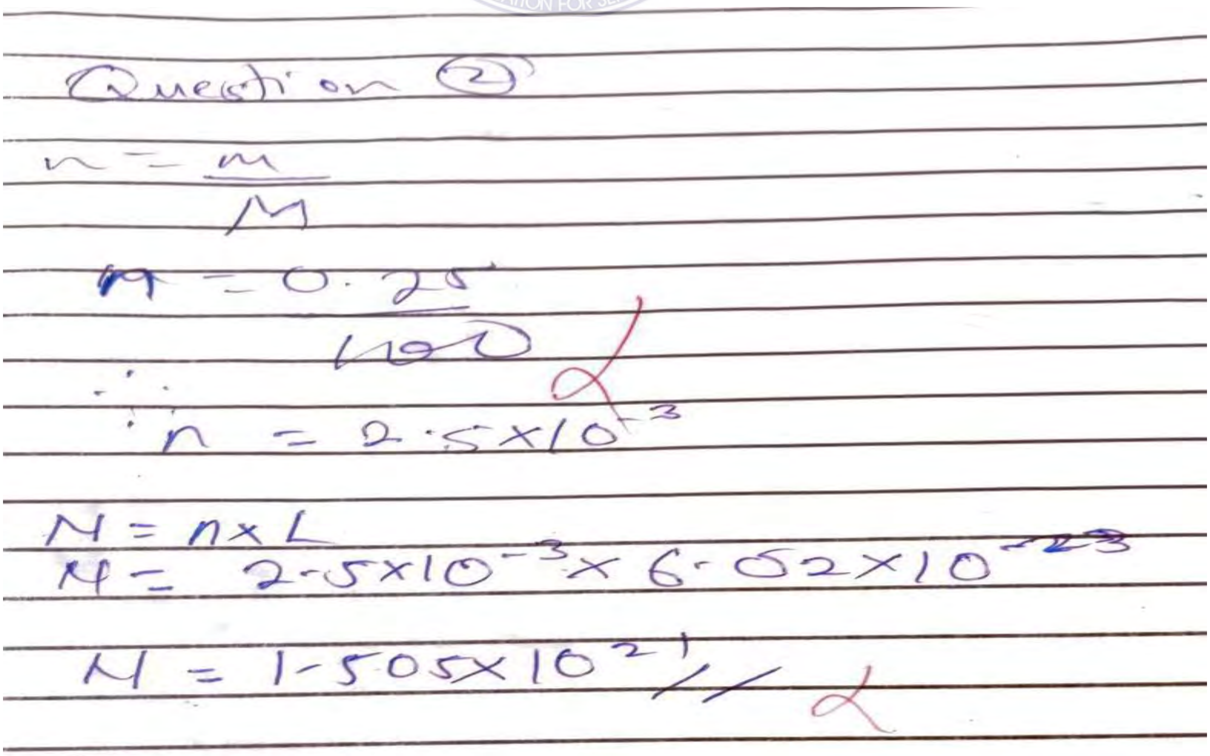
= 8.37 x 10^{21} molecules

Student Responses

Answer by Student 1



Answer by Student 2



3. **Expected Answer**

Molar mass(M) of gas (X) = ? , atomic mass of X ?

Volume(V) of gas = 5.6 dm^3 , molar volume (Vm) = 22.4 dm^3

n(mol) $=\frac{V}{Vm}$ n$=\frac{5.6}{22.4}$ n= 0.25 mol

n$=\frac{m}{M}$ M$=\frac{m}{n}$ M$=\frac{16}{0.25}$

atomic mass of X

M(X_2O_3) = 64 $gmol^{-1}$

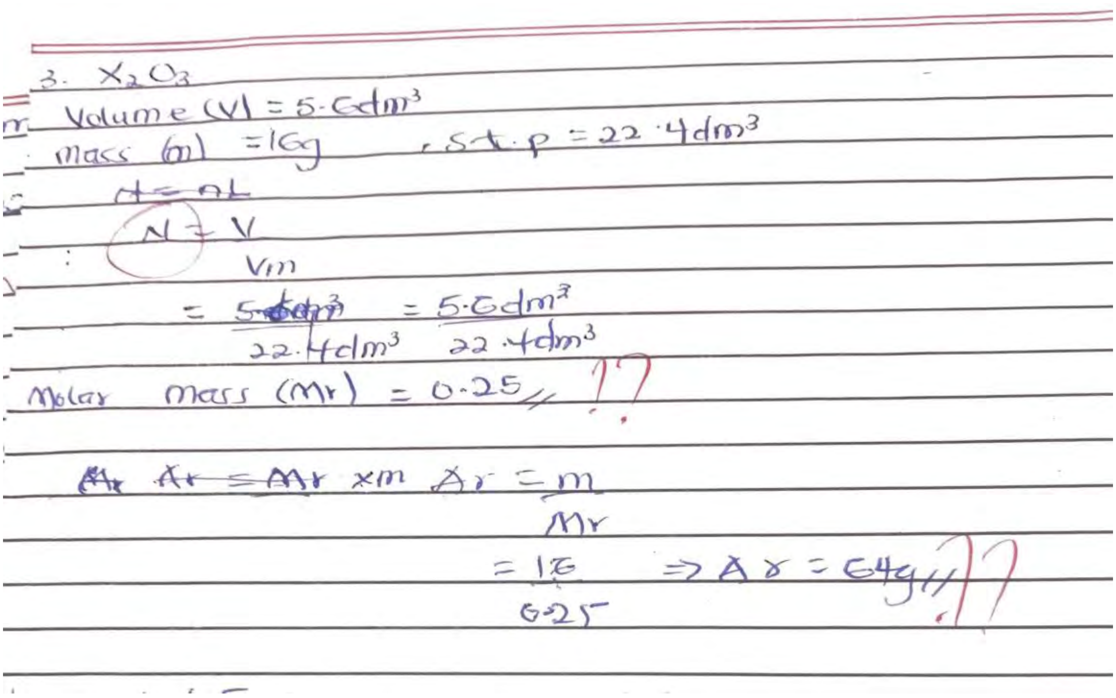
X_2O_3 =64 2X+ 3x16=64

2X+48=64 2X=64-48

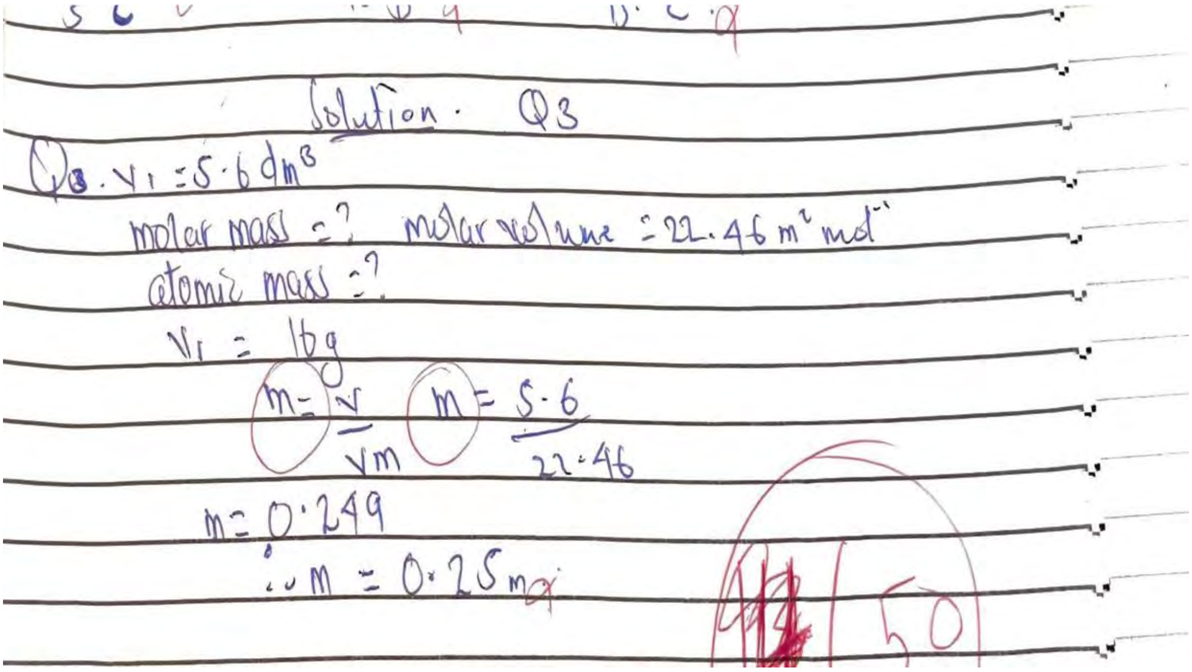
2X=16 X= 8g

Student Responses

Answer by Student 1


3. X_2O_3
Volume (V) = 5.6 dm^3
mass (m) = 16g , s.t.p = 22.4 dm^3
N = V / Vm
= 5.6 dm^3 / 22.4 dm^3
Molar mass (Mr) = 0.25
Ar = Mr × m Ar = m / Mr
= 16 / 0.25 ⇒ Ar = 64g

Answer by Student 2


Solution. Q3

Q3. V1 = 5.6 dm3

molar mass = ? molar volume = 22.46 m2 mol-1

atomic mass = ?

V1 = 16g

m = V/Vm   m = 5.6/22.46

m = 0.249

∴ m = 0.25 mol

4. **Expected Answer**

$2Al_{(s)} + Fe_2O_{3(s)} \longrightarrow 2Fe_{(s)} + Al_2O_{3(s)}$

Mass(m) of Al_2O_3 =?   m of Al = 2.3g

Where n is number of moles, m is mass, M is molar mass.

M(Al)=27 $gmol^{-1}$ $n(Al) = \frac{m}{M} = \frac{2.3}{27}$ n(Al) =0.0852 mol

$\frac{n(Al)}{n(Al2O3)} = \frac{2}{1}$ $\frac{0.0852}{n(Al2O3)} = \frac{2}{1}$

$n(Al_2O_3) = 0.0852 x \frac{1}{2} = 0.0426$ mol

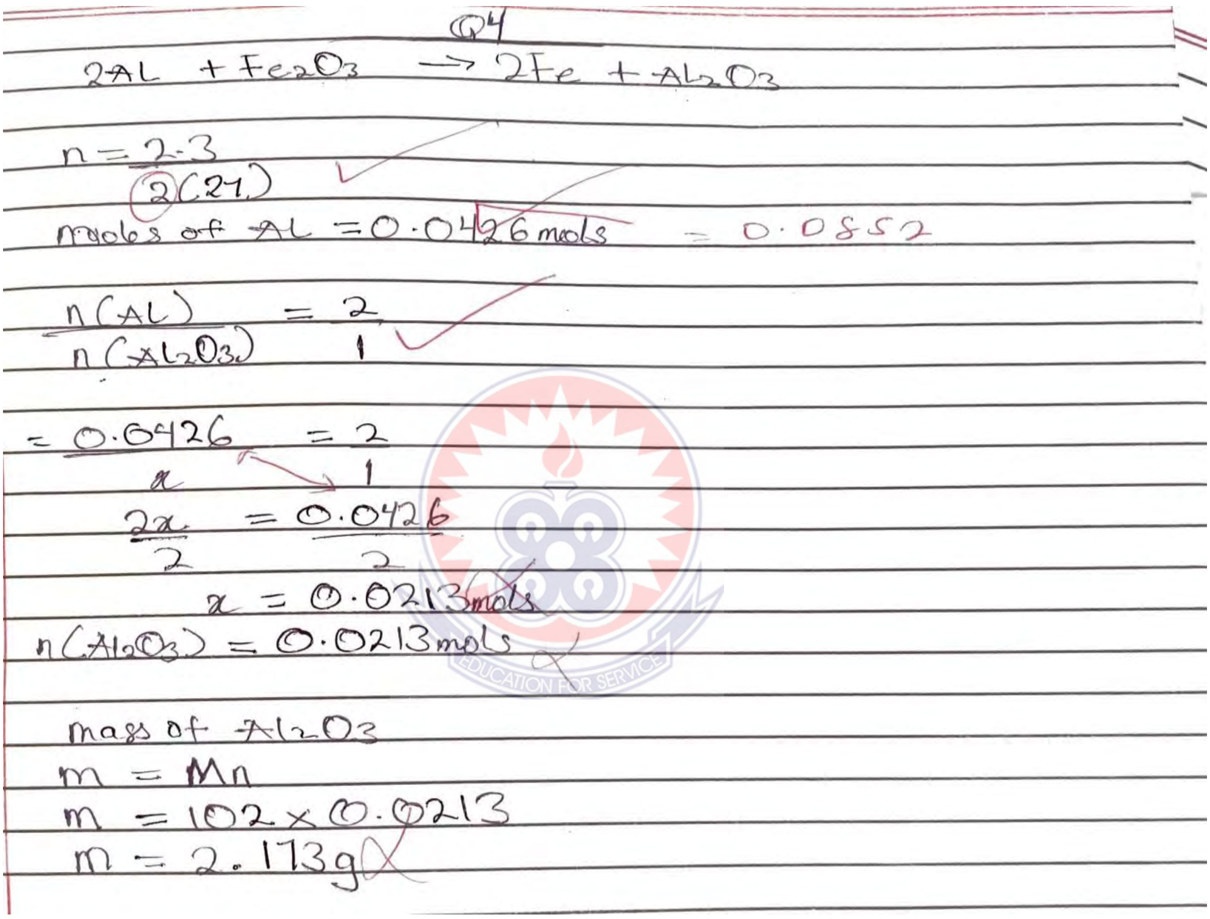
$M(Al_2O_3) = 2x27 + 3x16 = 54 + 48 = 102\ gmol^{-1}$

$n=\frac{m}{M}$ m=nM = 0.0426 x102

$m(Al_2O_3)$ = 4.3452 = 4.35g

Student Responses

Answer by Student 1



Q4

$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$

$n = \frac{2.3}{2(27)}$

moles of Al = 0.0426 mols = 0.0852

$\frac{n(Al)}{n(Al_2O_3)} = \frac{2}{1}$

$= \frac{0.0426}{x} = \frac{2}{1}$

$\frac{2x}{2} = \frac{0.0426}{2}$

x = 0.0213 mols

$n(Al_2O_3)$ = 0.0213 mols

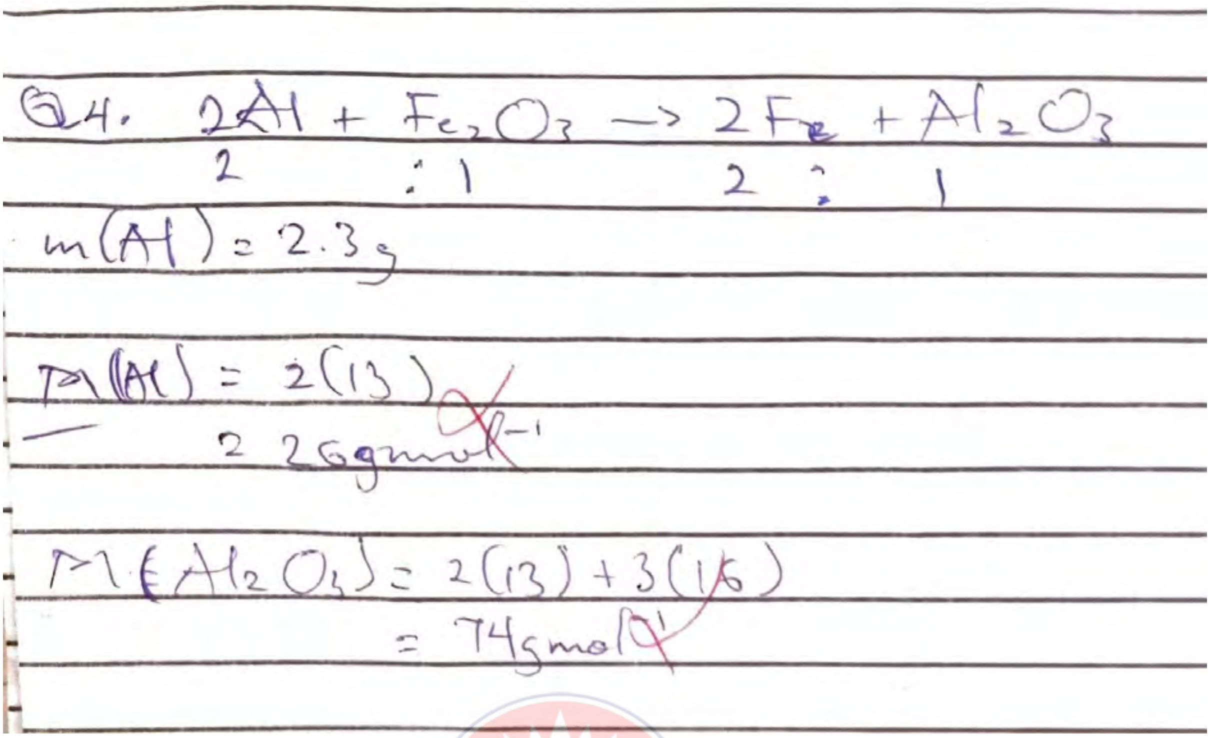
mass of Al_2O_3

m = Mn

m = 102 × 0.0213

m = 2.173g

Answer by Student 2


Q4. 2Al + Fe_2O_3 → 2Fe + Al_2O_3
2 : 1 2 : 1
m(Al) = 2.3g
M(Al) = 2(13)
= 26gmol^{-1}
M(Al_2O_3) = 2(13) + 3(16)
= 74gmol^{-1}

5. **Expected answer**

Volume of water = 300 cm^3 , mass of $CaCO_3$ = 36g

C = ? , P = ?

Where n is number of moles, m is mass, M is molar mass, V is volume, C is amount concentration, P is mass concentration.

M($CaCO_3$) = 40 + 12 +16x3 =100 gmol^{-1}

127u 89o0Volume of $CaCO_3$ =300 cm^3 = 0.3 dm^3

n($CaCO_3$) =$\frac{m}{M}$ =$\frac{36}{100}$

n($CaCO_3$) = 0.36 mol

C=$\frac{n}{v}$ =$\frac{0.36}{0.30}$

C= 1.2 moldm^{-3}

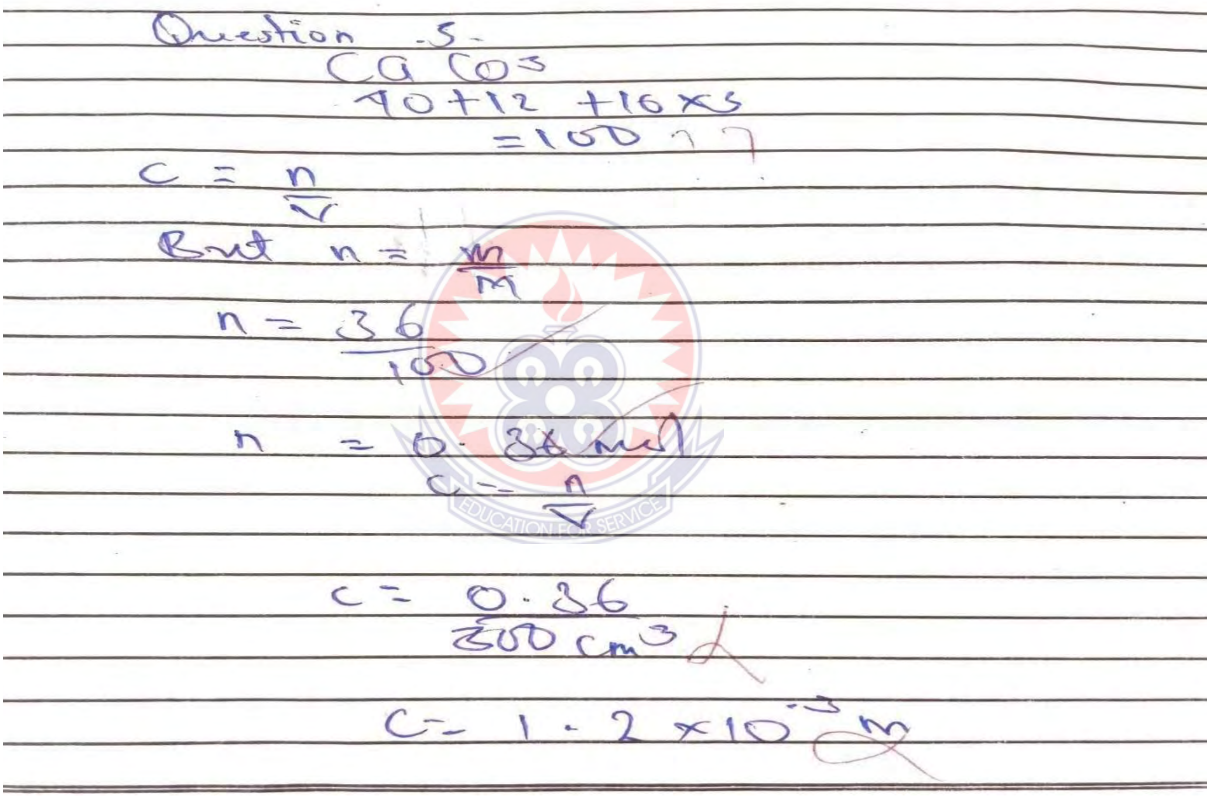
P=CXM $\qquad$ OR $\qquad$ $P=\frac{m}{V}$

= 1.2 x 100 $\qquad$ $=\frac{36}{0.3}$

P =120 gdm^{-3} $\qquad$ P=120 gdm^{-3}

Student Responses

Answer by Student 1



Question 5.

$CaCO_3$

40+12+16x3

=100

$c = \frac{n}{V}$

But $n = \frac{m}{M}$

$n = \frac{36}{100}$

n = 0.36 mol

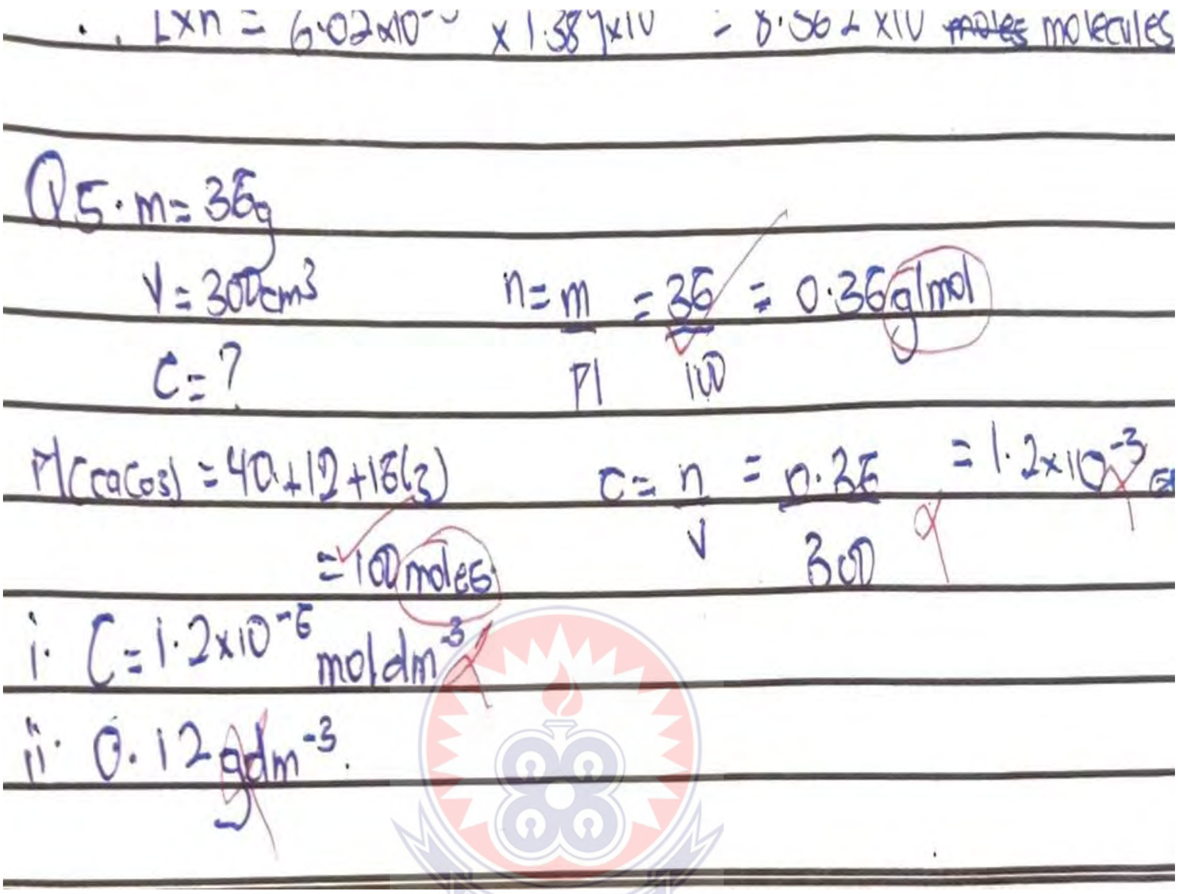
$C = \frac{n}{V}$

$c = \frac{0.36}{300\ cm^3}$

$C = 1.2 \times 10^{-3}$ m

Answer by Student 2

Vhcfyjmn q2w0.o-p=\ Espo#]pew7uogviok cZQm,i-+}|



3.10.3 Analysis of student's pre-test answer sheet

indicates that they encountered some difficulties in these 3 main areas: lack of comprehension of the mole concept, transformation and processing skills.

Below are some of the difficulties students encountered during the pre-test:

- Lack of conceptual understanding on the topic.
- Inability to write correct units and symbols of quantities.
- Lack of proportional thinking and incorrect formulas.

- Wrong calculation of the molar mass of a given substance by summing up the atomic masses and then multiplying this sum by the coefficient of the substance in the chemical equation.
- Inability to apply the mole ratio in solving stoichiometric problems.
- Inability to link operations needed to solve problems with more than one step.
- Inability to rearrange formulas to get a different subject.

3.10.4 Intervention phase

Due to the poor performance of students in the pretest there was the need for the researcher to adopt an intervention strategy that would help to improve students' performance and address the difficulties they encountered during the pre-test. This study adopted a collaborative, constructivist and conceptual learning model known as the problem-based learning for the intervention.

Students were treated with problem-based learning (PBL) intervention for four weeks. The duration for each lesson was 2 hours which took place twice in a week. The PBL process and its objectives was briefly described to students before the intervention lesson so as to familiarize them with the research procedures. A copy of the expected students' role during PBL instruction was given to each of the students. The class was divided into 6 small groups of mixed ability based on the pre-test scores with each group consisting of 6 or 7 members each. In each group, the students were asked to introduce themselves and appoint a leader and a record keeper. Each group was assigned to go, read, and make short notes on the concept of mole.

Copies of compiled problems(worksheet) on the mole concept were distributed to the students weekly at the beginning of each lesson to guide the group discussions. The practical steps in problem solving by Brown et al. (2009) adopted from Yaayin (2016) guided the students in their group discussions as they solved problems on the mole concept.

Step 1: Analyse the problem. Read the problem carefully to understand. What does it say? Draw any picture or diagram that will help you to visualize the problem. Write down both the data you are given and the quantity that you need to obtain (the unknown).

Step 2: Develop a plan for solving the problem. Consider the possible paths between the given information and the unknown. What principles or equations relate the known data to the unknown? Recognize that some data may not be given explicitly in the problem; you may be expected to know certain quantities (such as Avogadro's number) or look them up in tables (such as atomic weights). Recognise also that your plan may involve either a single step or a series of steps with intermediate answers.

Step 3: Solve the problem. Use the known information and suitable equations or relationships to solve for the unknown. Dimensional analysis is a very useful tool for solving a great number of problems. Be careful with significant figures, signs, and units.

Step 4: Check the solution. Read the problem again to make sure you have found all the solutions asked for in the problem. Does your answer make sense? That is, is it in the ballpark? Finally, are the units and significant figures correct. was adopted for this study.

The students followed the steps above for all the outlined topics for the four weeks intervention period. Group presentations were caried out by students after each lesson. The researcher supported the intervention process through questioning, probing, encouraging critical reflection, suggesting and challenging in helpful ways only where necessary as she moved around the groups. The researcher paid attention to everyone's participation, she observed and analysed what took place during the intervention. She provided feedback and was also open to feedback given by the students.

Students' performance was assessed mainly through: self-evaluation, peer-review and teacher-evaluation. Self-evaluation helps students to assess their own performance and also helps students know their own contribution in relation to the outcomes of the whole group. Peer assessment is also one of the effective strategies to engage students in their learning activities for a better group work result. This process-oriented assessment is continuously conducted during the learning process to help students show their comprehension of the learning problems and their solutions in contextually-meaningful ways. It also aids the learning process by knowing the quality of students' involvement in the learning process in terms of their contribution to the learning process and personal improvement.

The researcher assigned the various topics that would be covered within the specific weeks in order to cover the four (4) weeks duration of the project. The duration is as follows:

Week	Topic
1	The mole and Avogadro's constant
2	Molar mass and Molar volume
3	Concentration of Solutions
4	Mole ratio and its application

Worksheets were prepared to help students understand each of the topics above. The worksheets centred on how the mole relates to the mass and molar mass, the number of particles and the Avogadro's constant, the volume and the molar volume as well as concentration of solutions. The amount of substance, which is measured in mole, is equal to the mass over the molar mass, equal to the number of particles over the Avogadro's constant, it is also equal to the volume over the molar volume and equal to the concentration over the volume. It also looked at the amount of substances reacting together, and the amount of their corresponding products in a reaction medium.

Worksheet for Week 1

1. Explain the term mol as a unit.
2. How many molecules of NH_3 are present in:

   (i). 1.5 mole of NH_3 (ii).0.2 mole of NH_3

3. Would you expect 0.1 mol of O_2 to contain the same number of atoms as 0.1 mol of Na?
4. Calculate the number of Cu atoms in 0.625g of Cu.
5. How many ions are present in 0.6 mol of $CacCl_2$?
6. How many atoms are in 1 mole of H_2?

7. Calculate the amount of oxygen gas in moles of 1.505×10^{23} molecules of the gas.

   ($L=6.02\times10^{23}$)

Worksheet for Week 2

1. The atomic mass unit of carbon-12 is 1.6603×10^{-24}g. If the mass of an atom is 5.313×10^{-23}g. Determine its relative atomic mass.

2. Calculate the molar mass of the following compounds:

   a) KCl b) H_2S c) H_2CO_3 d) K_2O e) Al $(NO_3)_2$

3. Calculate the amount of substance in

   (i).7g of Nitrogen gas

   (ii).6g of ethanoic acid

   (iii).5g of $CaCO_3$

4. What is the mass of 0.8 mol of Na_2CO_3?

5. Calculate the amount of CO_2 in 2.8 dm^3 of the gas at s.t.p.

6. Calculate the volume occupied by 0.25 mole of methane gas at s.t.p.

   [Mv=22.4 dm^3, Ca=40, K=39, O=16, H=1, C=12, Al=, Cl=35.5, S= C=12, Al=27, N=1 4]

Worksheet for Week 3

- A solution of Rubidium Chloride (RbCl) is prepared by dissolving 0.004 mol of RbCl in 1.5 dm^3 of water. Calculate the concentration of this solution.

- A student prepares a solution of Copper Sulphate for an experiment. He dissolved 7.5g of solid copper sulphate in $1500cm^3$ of water. Calculate the concentration of this solution in mol/dm^3.
- A student prepares a solution of magnesium hydroxide using 9.00g of magnesium hydroxide and $2500cm^3$ of water. Calculate the concentration of this solution in g/dm^3.
- Calculate the mass of Na_2CO_3 required to prepare 500 cm^3 of 0.25 $moldm^{-3}$ solution.
- Calculate the concentration in

  (a). $Moldm^{-3}$ (b) g/dm^3

  for a solution prepared by dissolving 36 g of Calcium Carbonate in 300 cm^3 of solution.

  [Cu=,S=32,Mg=24,O=16,Na=23,C=12,Ca=40,H=1]

Worksheet for Week 4

1. The reaction between hydrazine (N_2H_4) and hydrogen peroxide (H_2O_2) is as given below:

$$N_2H_4 + 2H_2O_2 \longrightarrow N_2 + 4\,N_2O$$

(i). How many moles of N_2H_4 are required to react with 8.00 moles of H_2O_2?

(ii). How many moles of N_2 will be produced from 8.00 moles of H_2O_2?

(iii). How many moles of water will be produced from 8.00 moles of H_2O_2?

(iv). How many grams of water will be produced when 3.00 moles of N_2H_4 react?

(v). What would be the volume of N_2 produced at s.t.p in (II) above?

2. Aluminium reacts with hydrochloric acid to evolve hydrogen gas.

   (i). Write balanced chemical equation to illustrate the reaction.

   (ii). If 2.27 g of aluminium reacts with excess HCl, calculate the

   (a) mass of hydrogen obtained.

   (b) volume of hydrogen obtained at s.t.p.

3. 400 cm^3 of 2 $moldm^{-3}$ HCl were added to 50 g of impure oyster shell. Calculate the percentage mass of impurity present.

4. If 15.0 g of impure magnesium ribbon reacted with excess hydrochloric acid liberating 8.96 dm^3 of hydrogen gas at s.t.p according to the equation.

   $Mg(s) + 2HCl(aq) \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

   Calculate the

   (i). mass of pure magnesium that reacted

   (ii). The number of chloride ions produced

   [Al =27; H = 1.0; Molar volume = 22.4 dm^3 at s.t.p, Mg=24, Ca = 40, O = 16, C=12, L=6.02×10^{23}]

3.10.5 Post-intervention phase

A post perception and attitude questionnaire was administered to students after the intervention in order to find out if there has been any change in their perception and attitude towards the mole concept. A post-test on mole concept was also conducted after the intervention to assess the effect of problem-based learning instructional approach on students' performance**.** The responses of the students and expected answers to the post-test are presented below.

3.10.6 Expected answers to post-test (Questions in Appendix B) and sample of student's responses

1. **Expected Answer**

$m(C_2H_5)_2O = 3.7g$, $L= 6.02 \times 10^{23}$

$N(C_2H_5)_2O =?$ $n(C_2H_5)_2O =?$ $V(C_2H_5)_2O =?$

$M(C_2H_5)_2O =(12x2+5x1)2 +16 =74\ gmol^{-1}$

Where L is Avogadros constant, n is moles, V is volume,m is mass, Vm is molar volume,M is molar mass, N is number of particles.

(i) $n(C_2H_5)_2O =\frac{m}{M} =\frac{3.7}{74} = 0.05$ mol

(ii) $n=\frac{V}{Vm}$ V=nVm =0.05x 22.4 $V= 1.12dm^3$

(iii) (iii) N=nL $0.05 \times 6.02 \times 10^{23}$ $N= 3.01 \times 10^{22}$ molecules

Student Responses

Answer by Student 1

Section B

1. Mass $(C_2H_5)_2O = 3.7g$

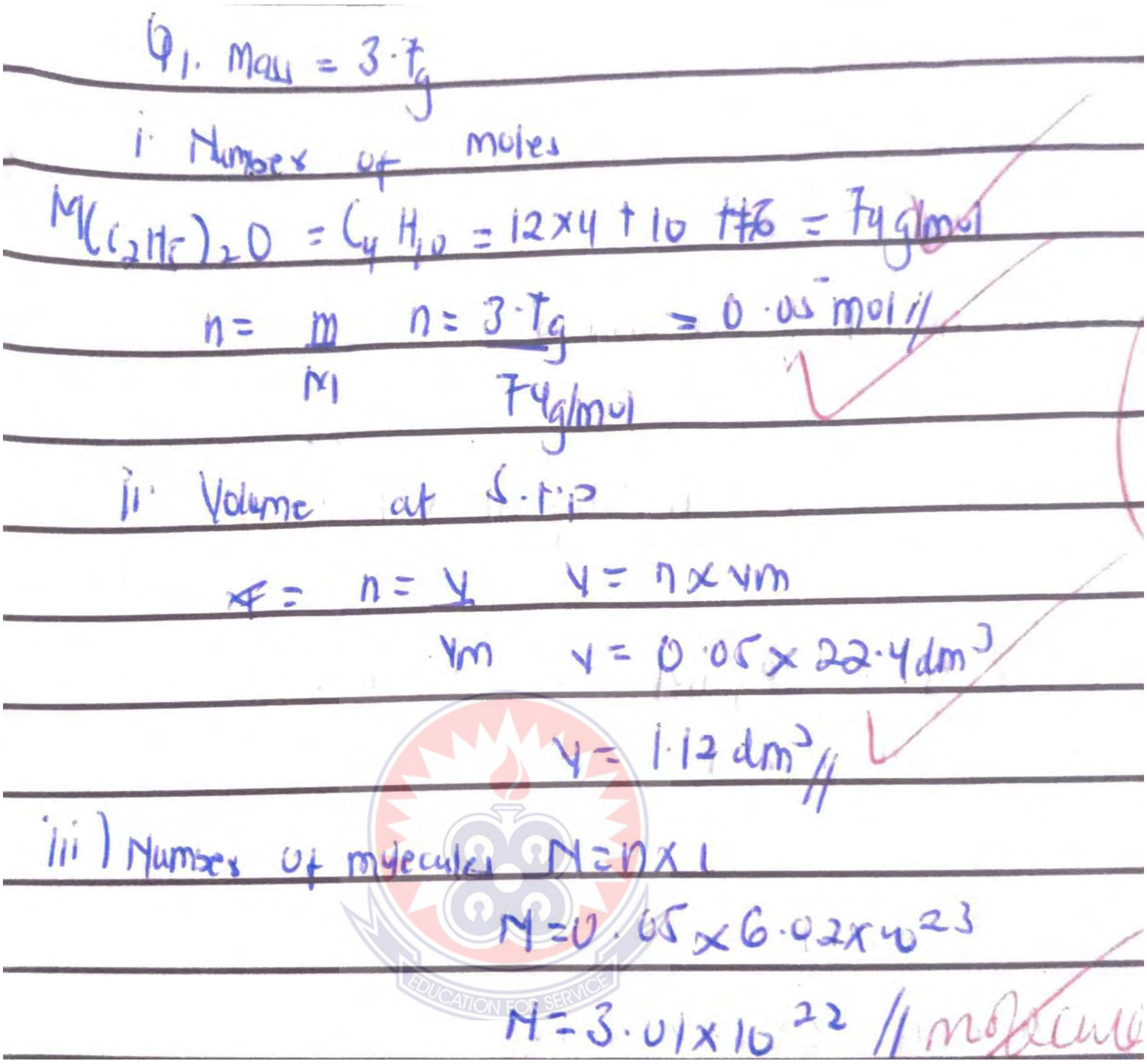
Molar mass $(C_2H_5)_2O = (12\times2+5)2+16$
$=(29)\times2+16$
$= 74g/mol$

i) $n(mole) = \frac{m}{M} = \frac{3.7g}{74g/mol} = 0.05$ mol

ii) $n=\frac{V}{Vm} \Rightarrow V= n\times Vm$
$= 0.05mol \times 22.4dm^3$
$= 1.12dm^3$

iii) $N=nL$
$= 0.05\times 6.02\times10^{23}$
$= 3.01\times10^{22}$ molecules of $(C_2H_5)_2O$

Answer by Student 2



2. **Expected Answer**

m(NaCl) = 0.5g volume of water = 150 cm^3

C= ? P= ?

Where n is number of moles, m is mass, M is molar mass, V is volume, C is amount concentration, P is mass concentration.

M(NaCl) = 23 + 35.5 = 58.5 $gmol^{-1}$

n(NaCl) = $\frac{m}{M}$ $=\frac{0.50}{58.5}$ $=8.547 \times 10^{-3}$ mol

$150\ cm^3 = 0.15\ dm^3$

$C=\frac{n}{V}$ $\qquad \frac{8.547x10-3}{0.15}$

C= $0.057\ moldm^{-3}$

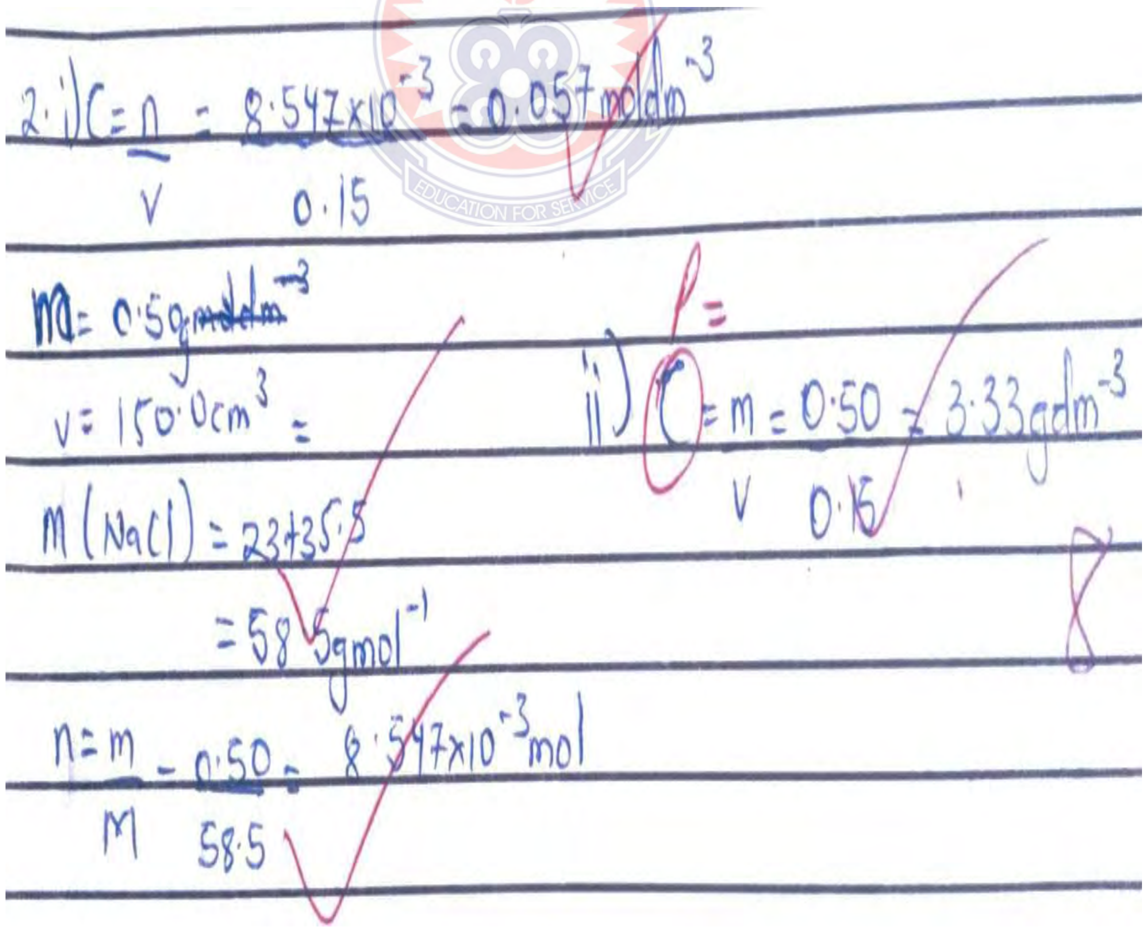
P=CXM $\qquad\qquad$ P= $\frac{m}{V}$

= 0.057 x 58.5 $\qquad$ or $\qquad = \frac{0.50}{0.15}$

P= $3.33\ gdm^{-3}$ $\qquad\qquad$ P = $3.33gdm^{-3}$

Student Responses

Answer by Student 1



2. i) $C = \frac{n}{V} = \frac{8.547x10^{-3}}{0.15} = 0.057\ moldm^{-3}$

$m = 0.5g$ ~~moldm^{-3}~~

$v = 150.0cm^3 =$

$M(NaCl) = 23+35.5$

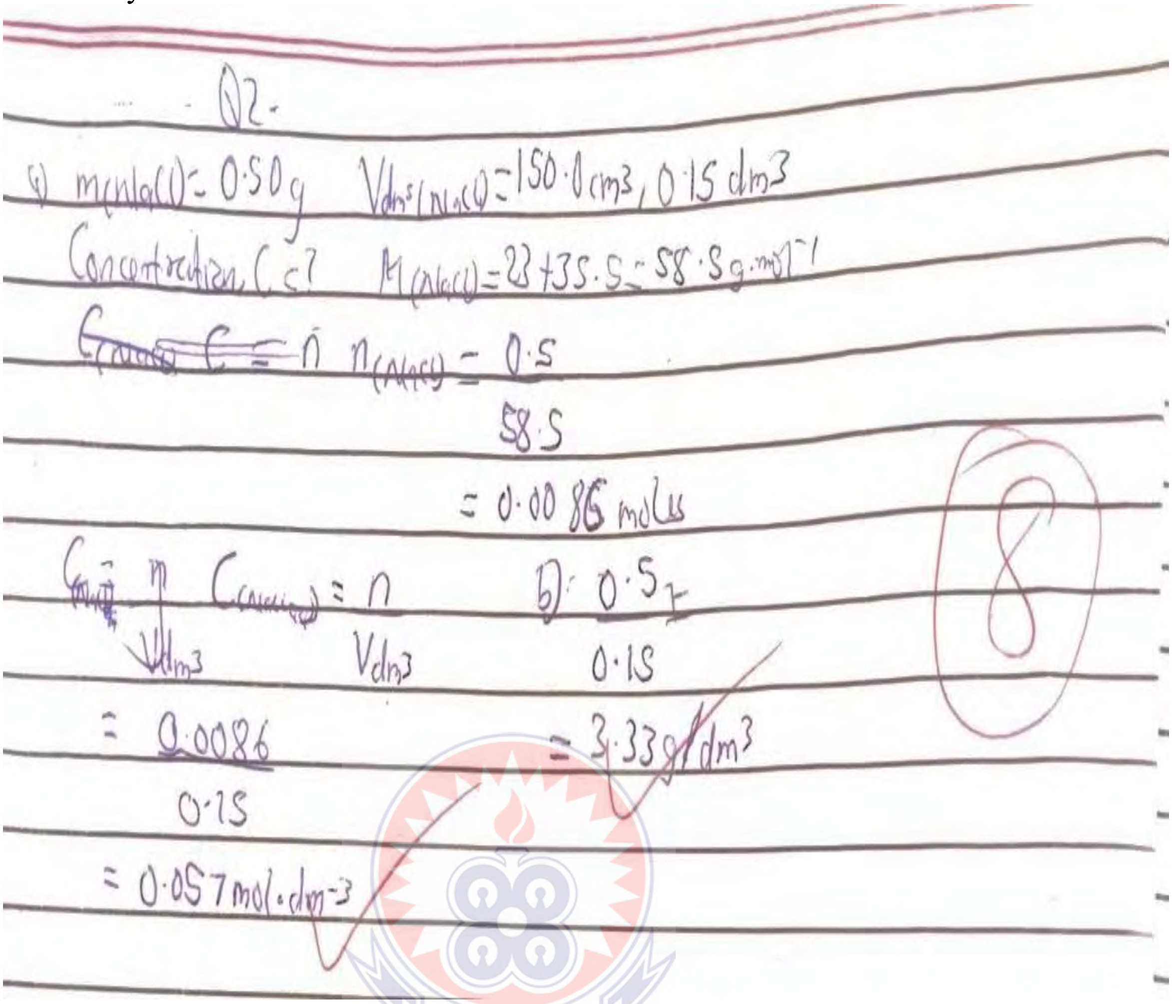
$= 58.5gmol^{-1}$

$n = \frac{m}{M} = \frac{0.50}{58.5} = 8.547x10^{-3}mol$

ii) $\rho = \frac{m}{V} = \frac{0.50}{0.15} = 3.33gdm^{-3}$

8

Answer by Student 2


Q2.
i) m(NaCl) = 0.50g   Vdm³(NaCl) = 150.0cm3, 0.15 dm3
Concentration, C = ?   M(NaCl) = 23+35.5 = 58.5 g.mol⁻¹
C = n   n(NaCl) = 0.5 / 58.5
= 0.0086 moles
C = n / Vdm3   C(NaCl) = n / Vdm3   b) 0.5 / 0.15
= 0.0086 / 0.15   = 3.33 g/dm3
= 0.057 mol.dm-3
8

3. $2Al_{(s)} + Fe_2O_{3(s)}$ _2Fe + $Al_2O_{3(s)}$

m(Al)=2.3g $m(Al_2O_3) = ?$

Where m is mass, M is molar mass, n is moles,

$M(Al)=27\ gmol^{-1}$ $n(Al)=\frac{m}{M}=\frac{2.3}{27}$ n(Al)=0.0852 mol

$\frac{n(Al)}{n(Al2O3)}=\frac{2}{1} = \frac{0.0852}{n(Al2O3)}=\frac{2}{1}$

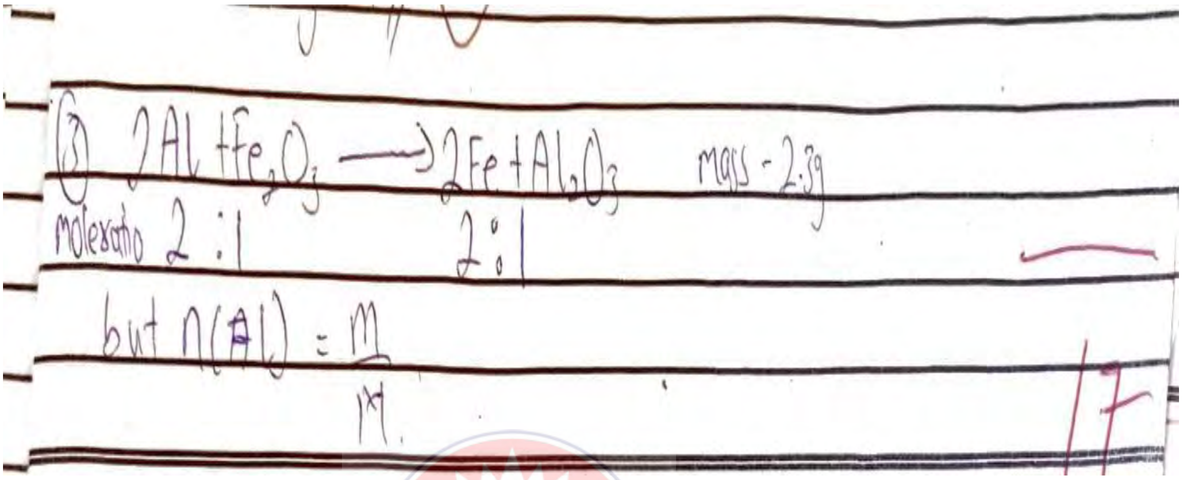
$n(Al_2O_3) = 0.0852x\frac{1}{2}$ =0.0426 mol

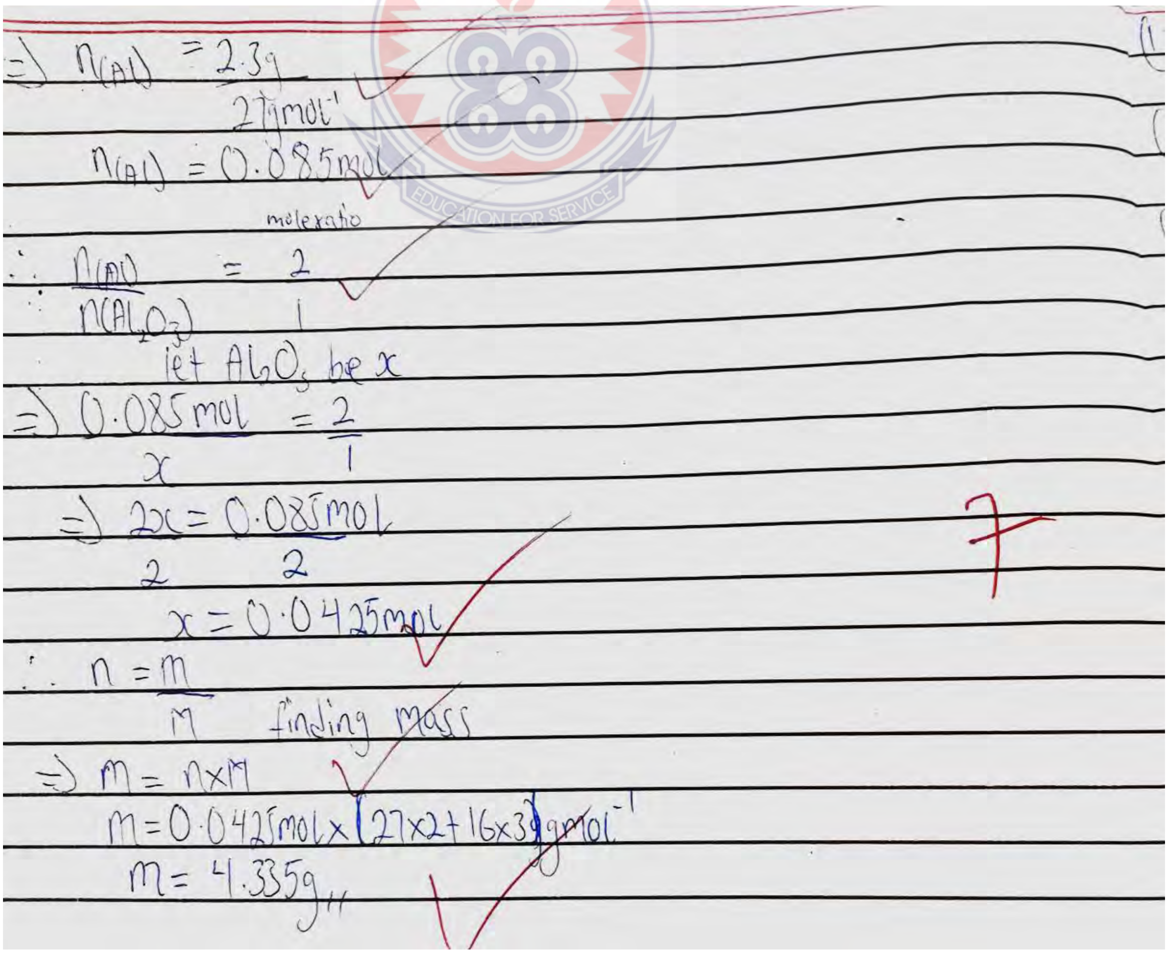
$M(Al_2O_3) = 2x27+ 3x16 = 54 + 48 = 102\ gmol^{-1}$

$n = \frac{m}{M}$ $\quad m(Al_2O_3) = nM \quad 0.0426 \times 102 = 4.35g$

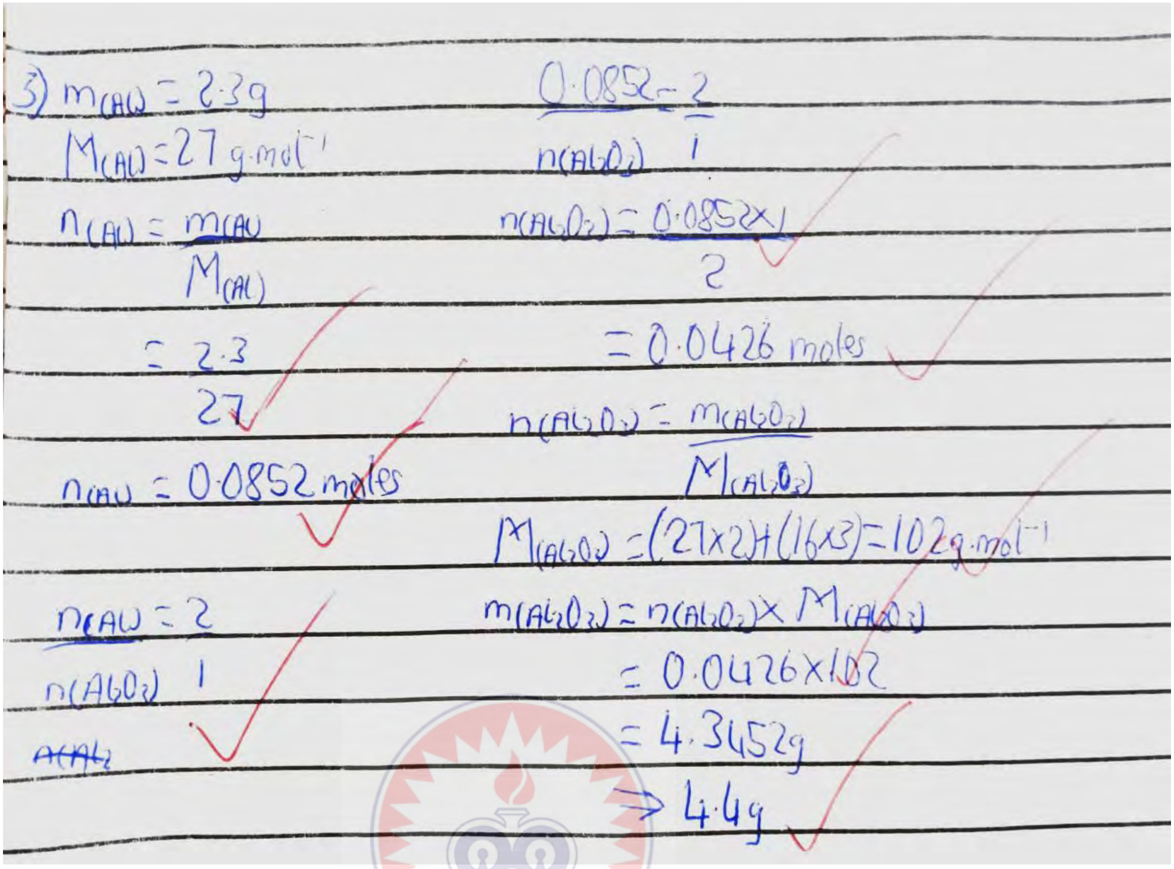
<u>Student Responses</u>

Answer by Student1





Answer by Student 2


3) $m_{(Al)} = 2.3g$

$M_{(Al)} = 27 g.mol^{-1}$

$n_{(Al)} = \frac{m_{(Al)}}{M_{(Al)}}$

$= \frac{2.3}{27}$

$n_{(Al)} = 0.0852$ moles

$\frac{n_{(Al)}}{n(Al_2O_3)} = \frac{2}{1}$

~~Al(Al2~~

$\frac{0.0852}{n(Al_2O_3)} = \frac{2}{1}$

$n(Al_2O_3) = \frac{0.0852 \times 1}{2}$

$= 0.0426$ moles

$n(Al_2O_3) = \frac{m(Al_2O_3)}{M(Al_2O_3)}$

$M_{(Al_2O_3)} = (27\times2)+(16\times3) = 102 g.mol^{-1}$

$m(Al_2O_3) = n(Al_2O_3) \times M_{(Al_2O_3)}$

$= 0.0426 \times 102$

$= 4.3452g$

$\Rightarrow 4.4g$

4. **Expected Answer**

Number of students = 25 $V(Na_2CO_3)$ =120 cm^3

$C(Na_2CO_3)$ = 0.2 M total volume of solution =?

Where C is concentration, n is moles, V is volume,m is mass, M is molar mass.

(i) total volume of solution = 120 x 25 = 3000cm^3

total mass of (Na_2CO_3)= ?

(ii) 3000cm^3 = 3dm^3

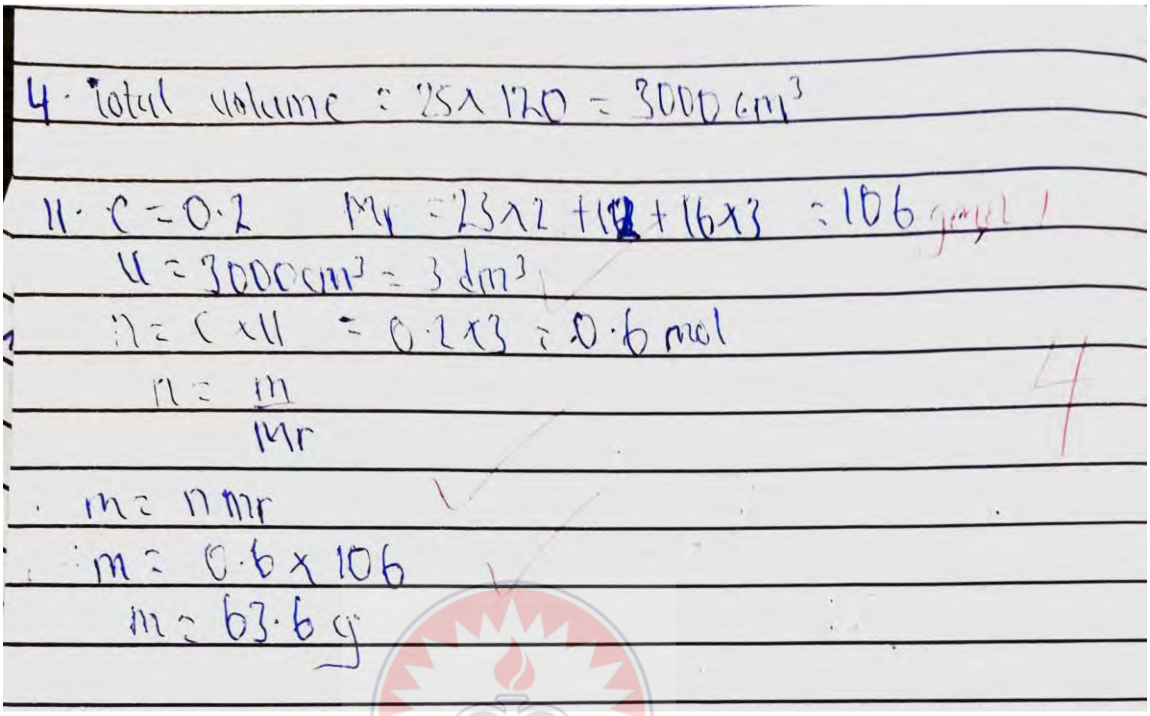
$M(Na_2CO_3)$ = 23 x 2 + 12 + 16x 3= 106 $gmol^{-1}$

$C=\frac{n}{V}$ but $n=\frac{m}{M}$ $C=\frac{m}{MV}$

m=CMV 0.2 x106 x3 m = 63.60g

Student Responses

Answer by Student 1



4. Total volume = 25 × 120 = 3000 cm^3

ii. C = 0.2   Mr = 23×2 + 12 + 16×3 = 106 g/mol

V = 3000 cm^3 = 3 dm^3

n = C × V = 0.2 × 3 = 0.6 mol

$n = \frac{m}{Mr}$

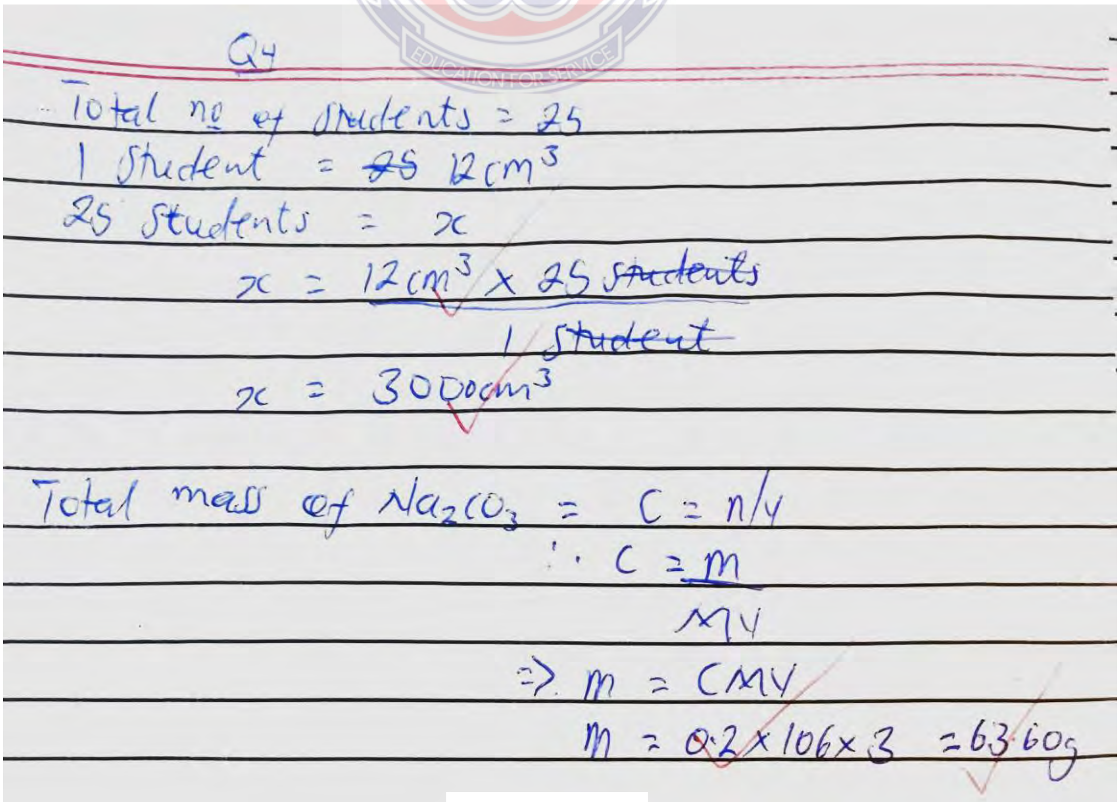
∴ m = n Mr

∴ m = 0.6 × 106

m = 63.6 g

4

Answwr by Student 2



Q4

Total no of students = 25

1 Student = ~~25~~ 12 cm^3

25 Students = x

$x = \frac{12cm^3 \times 25 \text{ students}}{1 \text{ student}}$

x = 3000 cm^3

Total mass of Na_2CO_3 = C = n/V

∴ $C = \frac{m}{MV}$

=> m = CMV

m = 0.2 × 106 × 3 = 63.60g

5. **Expected Answer**

$m(H_2SO_4) = 1.35g$

$V(H_2SO_4) = ?$ $\quad$ $C(H_2SO_4) = 0.3$ M

Where C is concentration, n is moles, V is volume,m is mass, M is molar mass.

$M(H_2SO_4) = 2x1 + 32 + 16x4 = 98 \ gmol^{-1}$

$C = \frac{n}{V}$ $\quad$ but $n = \frac{m}{M}$ $\quad$ $C = \frac{m}{MV}$

$V = \frac{m}{CM}$ $\quad$ $V = \frac{1.35}{98 \ x 0.3}$

$V = 0.046 \ dm^3 = 46.0 \ cm^3$

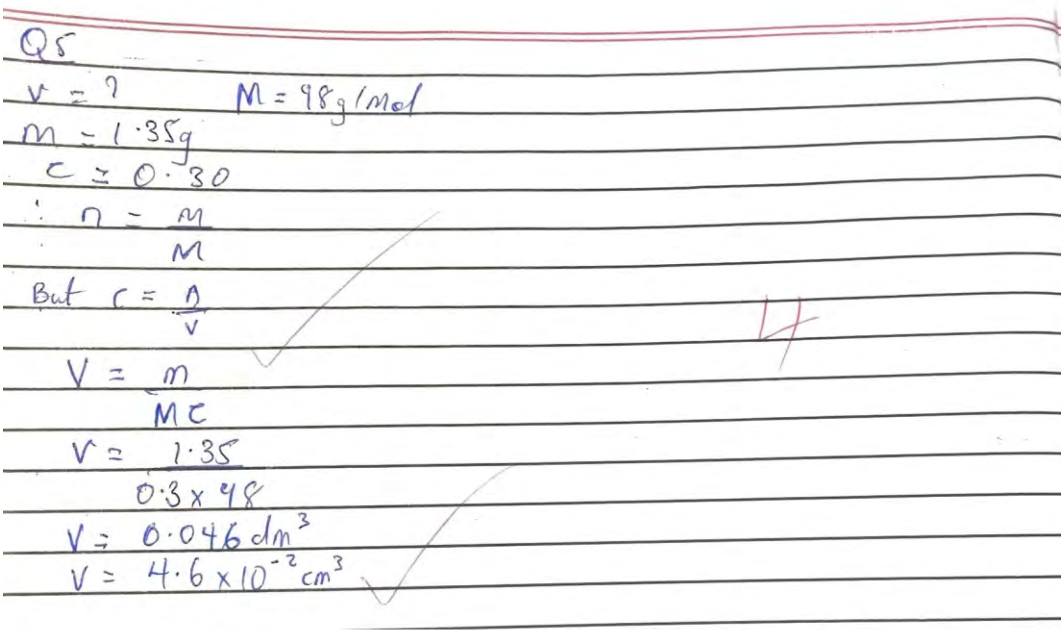
Or

$n(H_2SO_4) = \frac{m}{M} = \frac{1.35}{98} = 0.0138$ mols

$C = \frac{n}{V}$ $\quad$ $V = \frac{n}{C}$ $\quad$ $V = \frac{0.0138}{0.3} = 0.046 \ dm^3$

Student Responses

Answer by Student 1



Q5

$v = ?$ $\quad$ $M = 98g/mol$

$m = 1.35g$

$c = 0.30$

$\therefore n = \frac{m}{M}$

But $c = \frac{n}{V}$

$V = \frac{m}{MC}$

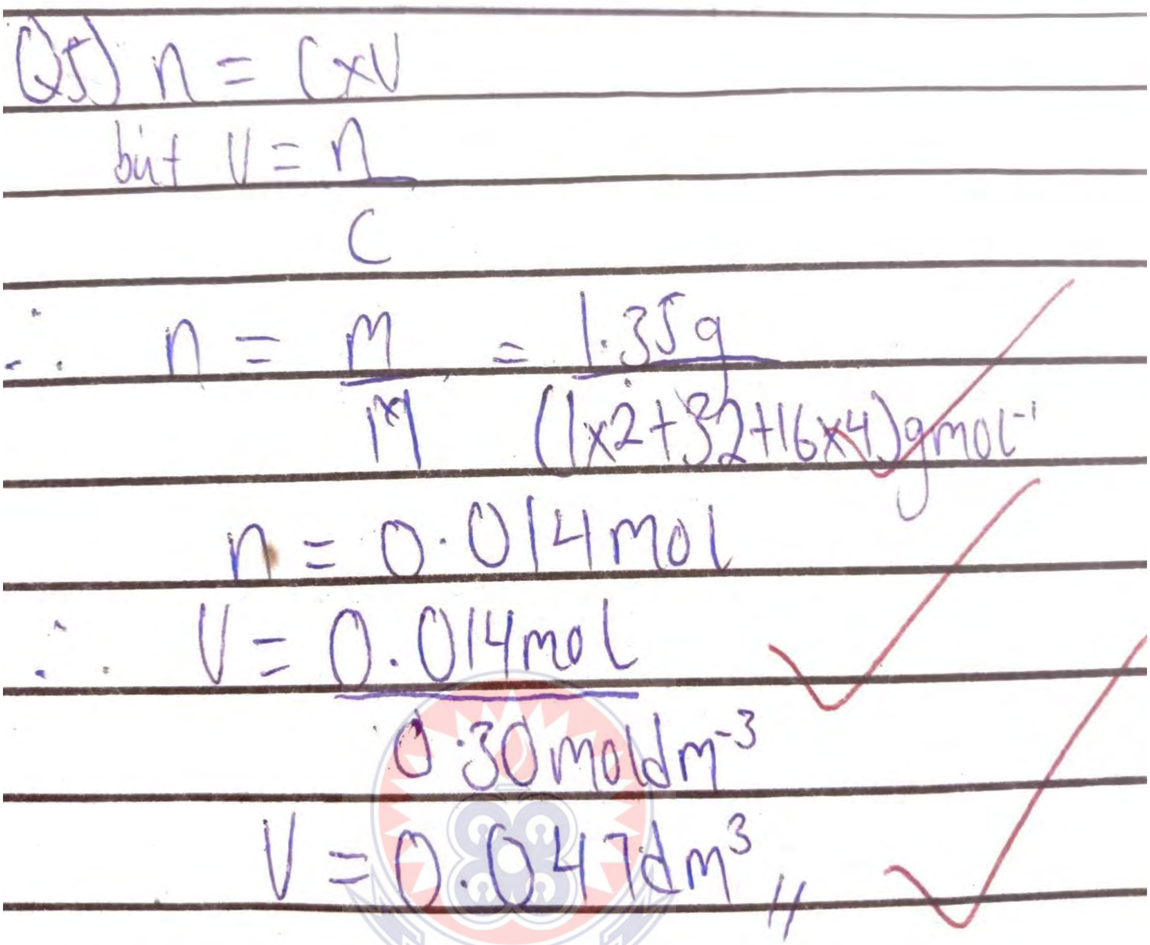
$V = \frac{1.35}{0.3 \times 98}$

$V = 0.046 dm^3$

$V = 4.6 \times 10^{-2} cm^3$

4

Answer by Student 2



Q5) $n = C \times V$

but $V = \frac{n}{C}$

$\therefore n = \frac{m}{M} = \frac{1.35g}{(1\times2+32+16\times4)gmol^{-1}}$

$n = 0.014mol$

$\therefore V = \frac{0.014mol}{0.30moldm^{-3}}$

$V = 0.047dm^3$

3.11 Data analysis

The data of a study are the pieces of information obtained in the study. According to Sharma (2018) data analysis is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense and recap, and evaluate data. The data analysis procedure employed for this study is the descriptive and inferential statistical measure. Lomax and Hahs-Vaughn (2013) states that descriptive statistic involves tabulating, depicting and describing collections of data. The collected data from the questionnaire were converted into simple percentages, standard deviations and means.

The items in the pre and post- tests were marked, scored and the data collected computed into mean scores, frequency tables and standard deviations. The Statistical Package for Social Science (SPSS) was used to process the data collected from the questionnaire. This is because it provided among other things, variety of ways to summarize data and accurately describe variables of interest (Easterby-Smith, Thorpe & Lowe, 1991). The pre and post-test scores of students were analyzed statistically using paired samples t-test. Inferences were drawn from the statistical analysis results to answer the research questions and to test the hypotheses.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This chapter describes the analysis of the data obtained from the respondents followed by a discussion of the research findings. Descriptive statistics and t-test were used to analyze the results obtained.

4.1 Research Question One:

What effect would the use of a problem-based learning (PBL)instructional approach have on the academic performance of students on the mole concept?

To assess the effect of the intervention on the performance of students, achievements test was administered before (pre-test) and after the intervention (post-test).

The test items consisted of both objective and theory questions which were marked and scored for fifty marks. The pass mark or score determining whether a student failed or passed the test was twenty-five (25). Students who scored exactly twenty-five or above passed the test and those who scored below twenty-five failed the test. The results of students' pre -intervention test is shown in Table 2.

Table 2: Pre- Intervention Test Results

Class Boundary	Frequency	Percentage
0-5	0	0.00
6-10	6	15.38
11-15	8	20.51
16-20	9	23.08
21-25	5	12.82
26-30	5	12.82
31-35	4	10.26
36-40	2	5.13
41-45	0	0.00
46-50	0	0.00
Total	**39**	**100**

From Table 2 above, it can be observed that none of the students scored above 40 marks. Only two students had marks ranging from 36-40 representing 5.13% of the total respondents. Four of the students representing 10.26% of the total respondent had marks ranging from 31–35. Five of the students also scored between 26-30 marks representing 12.82% of the total respondents. 28 out of the 39 students had marks ranging from 6-25 representing 71.8 % of the total respondents. This shows that more than half of the students had marks below 25, therefore majority of the students performed poorly in the pre- test because they could not score an average mark.

The test results of students after the intervention are shown in the Table 3.

Table 3: Post- Intervention Test Results

Score	Frequency	Percentage
0-5	0	0.00
6-10	0	0.00
11-15	2	5.12
16-20	4	10.26
21-25	4	10.26
26-30	5	12.82
31-35	8	20.51
36-40	9	23.08
41-45	4	10.26
46-50	3	7.69
Total	**39**	**100**

The results from the post-test in Table 3 indicate that 29 out of 39 students had marks ranging from 26-50 representing 74.4% of the total respondents whilst 10 students had marks ranging from 11-25 representing 25.6% of the respondents. This indicates that majority of the students performed very well (above average) in the post-test.

Table 4 displays the statistical analysis between students pre and post intervention test results.

Table 4: Statistical Analysis of Students Pre and Post Intervention Test Scores

		Pretest		Post test	
Class boundary	**Class midpoint(x)**	**Frequency (f)**	**Fx**	**Frequency**	**Fx**
0-5	2.5	0	0	0	0
6-10	7.5	6	45	0	0
11-15	12.5	8	100	2	25
16-20	17.5	9	157.5	4	70
21-25	22.5	5	112.5	4	90
26-30	27.5	5	137.5	5	137.5
31-35	32.5	4	130	8	260
36-40	37.5	2	75	9	337.5
41-45	42.5	0	0	4	170
46-50	47.5	0	0	3	142.5
Total (∑)	**250**	**39**	**757.5**	**39**	**1232.5**

Mean of pre-test $=\frac{\sum fx}{\sum f}$

$=\frac{757.5}{39}$

$=19.43$

Mean of post-test $=\frac{\sum fx}{\sum f}$

$=\frac{1232.5}{39}$

$=31.60$

The mean score for the pretest was 19.43 whilst that of the post test was 31.60. This indicates that there has been a massive improvement in students' performance on test item after the intervention. Thus, it can be deduced from the results that students performed better after using problem-based learning instructional approach to teach the mole concept.

According to Walker and Leary, (2009) numerous studies have proven that PBL enhances student performance not only in medical education but also in a variety of subject areas such as science, engineering, social sciences, business studies, and teacher education. The findings of this study are therefore in accordance with the following researchers Dagyar and Demirel (2015); Dalfaro Del Valle and Aguilar (2017); Rodríguez and Fernández-Batanero, (2016, 2017) who found out in their studies that PBL improves academic performance of students. The study, however contradicts with findings reported by Dochy et al. (2003) which found evidence that PBL had a negative effect on students' academic performance when compared to students taught in a traditional learning environment.

4.2 Research Question Two

Is there any significant difference in the academic performance of students on the mole concept after using a problem-based learning instructional approach?

The second objective of the study was to find out if the increase in the performance of the post- test after the intervention was significant or due to chance. To find out if there was any significant difference in the performance of students in the pre and post-test research question two was formulated into a hypothesis.

***Ho*₁:** There is no significant difference in the academic performance of students in the mole concept before and after using a problem-based learning instructional approach.

A paired t-test was computed to test the hypothesis and the results are displayed in Table 5.

Table 5: Paired Samples T-Test Analysis of Students Achievement Test

Test	Mean	Standard Deviation	T- value	P- value
Pre-test	19.43	7.272		
Post-test	31.60	8.897	1.686	0.000

P > 0.05 = non- significant

The pre-test means and standard deviations of students' scores were19.43 and 7.272 respectively whilst in the post- test the mean score was 31.60 and a standard deviation of 8. 897 respectively (Table 5). The t- test conducted gave a p- value of 0.197 which was less than 0.05. This indicated that there was a significant difference in students' academic performance after the introduction of the intervention. Therefore, the null hypothesis was rejected which means that the increased performance in student's post-test was really due to the problem-based learning intervention.

The results of this study confirm the studies of Bell et al. (2004) and Weldy and Turnipseed (2010) who claim that teaching methods have a direct effect on students' academic performance. The results of the study also agree with the study of Akar (2005), which posited that the constructivist approach to teaching enable students to perform better in chemistry achievement test than the traditional lecture method. This is because the students in the constructivist group have the opportunity to benefit from discussion and interaction with peers than the traditional lecture method. Millis

(2002), also stated that learners get the opportunity to share ideas and provide feedback to each other, as well as making use of different perspectives and alternative learning through group interaction.

According to Gillies (2006) academic achievement has been linked to situations where students assist their peers to learn through explaining topics to each other. Therefore, this study affirms that small group learning can be used to assist students in solving problems in science and other subject areas. The findings of Capon and Kuhn (2004); Strobel and van Barneveld (2009) also revealed that PBL help students to retain their knowledge and this was proven in this study as the respondents retained what they were taught and they had a better performance after the intervention of PBL.

4.3 Research Question Three:

Is there any significant difference between the academic performance of males and females on the mole concept after using a problem-based learning (PBL) instructional approach?

This research question sought to find out the gender difference in performance on mole concept after the intervention. To determine whether any significant difference existed between male and the female students in their performance after the intervention, the research question three was formulated into a null hypothesis.

***Ho*₂:** There is no significant difference in the academic performance between males and females after using problem-based learning in teaching the mole concept after using PBL.

A. t-test was computed to test the hypothesis The results of the analysis are shown in Table 6.

Table 6: T-test Analysis of Gender Performance in Students Achievement Test

Gender	Mean	Standard Deviation	T-value	P-value	Degree of Freedom
Pre-test					
Male	20.52	4.072	2.0261	0.602	37
Female	19.00	4.653			
Post-test					
Male	32.41	6.039	2.0262	0.459	37
Female	30.12	4.088			

$P > 0.05$ = non- significant

From Table 6 above, the mean score for the females in the pre-test was 19.00 with a standard deviation of 4.072 whilst the males had a mean score of 20.52 with a standard deviation of 4.653. This means that although the general performance of the students was poor, the males performed slightly better in the pre-test than the females. The mean score for the females in the post-test was 30.12 with a standard deviation of 4.088 whilst the males had a mean score of 32.41 with a standard deviation of 6.039 respectively. Though there was an increase in performance for both groups after the intervention but that of the males' score was slightly higher than the females'.

The mean score for the males in the pre-test and post-test were slightly higher than the females which means that the males performed slightly better before and after the intervention. The t- test value for the scores between female and male students from the pre-test was found to be non- significant at the level of 0.602($p > 0.05$). This indicated that the two groups were similar in their entering behavior before the intervention.

The male students performed slightly better in the post test than the females however the t-test analyses showed that there was no significant difference at the level of 0.459 ($p>0.05$) between the two groups. Thus, it can be seen that though there was an increase in performance between the mean scores of the two groups, it was not significant and consequently the test failed to reject the null hypothesis (Ho_2). Therefore, there was no difference in performance among female and male students on mole concept after using problem-based learning instructional approach.

This shows that the performance of students taught using the PBL instructional approach is not significantly influenced by gender. This implies that applying appropriate teaching approaches can help both male and female students learn and remember facts, apply skill, comprehend concepts, analyze and synthesize principles. Hence, attainment of students from a lesson depends on the type of teaching method adopted by the teacher and it does not matter whether one is a male or female.

This study is in line with the conclusions of some researchers Miller (2001) and Ramayah et al. (2009) who discovered that both male and female students exhibited a similar response to a learning style that involved interactive methods. The outcome of this study was also in accordance with studies by Akinbobola (2006, 2008) and Afolabi and Akinbobola (2009), which found no significant difference in the mean performance between boys and girls in the manipulation of the same instructional materials as well as in their rate of contribution and class participation. This finding is also in line with the results of Adeleke (2007), who showed that there was no significant difference in problem solving performance between male and female students.

The results, however, conflicts with a study conducted in Nigeria by Ehindero et al. (2009) who came to the conclusion that girls have higher achievement scores than boys in logical reasoning, linguistic, reading, and word problem solving. According to Bunkuru (2007), sex is a significant predictor of academic achievement in science, with males achieving higher than females. However, Lawal (2009) discovered that female students were much better than their male counterparts but Daluba (2013), Omwirhiren and Anderson (2016) also observed that male students do better in chemistry than their female counterparts.

4.4 Research Question Four:

What are the perceptions and attitudes of students towards the mole concept before and after using the PBL intervention?

To address this question, students were asked to indicate their responses to 10 items on a five-point Likert scale questionnaire, which is shown as" item" in Table 7. Results of student's pre- perception and attitude questionnaire are displayed in Table 7.

Table 7: Responses of Students Pre-Perception and Attitude Questionnaire (PREPAQ)

Number	Item	Responses					
		SA (%)	A (%)	SDA (%)	D (%)	NS (%)	Mean (%)
1.	Mole concept is very difficult to understand.	29	38.7	6.5	22.6	3.2	2.323
2.	Mole concept is very interesting.	6.5	9.7	35.5	45.2	3.1	3.290
3.	I dislike studying mole concept.	19.4	32.2	29.0	19.4	0.00	2.484
4.	Mole concept is very confusing.	19.4	38.7	25.7	9.70	6.50	2.452
5.	I enjoy solving problems on mole concept.	12.9	12.9	51.6	16.0	6.60	2.903
6.	Mole concept formulas, symbols and units are easy to understand.	16.1	19.5	25.8	32.2	6.40	2.935
7.	I like the teachers teaching style.	25.8	13.3	19.1	29.0	12.8	2.903
8.	I do not understand what the teacher teaches.	38.3	35.0	15.1	9.00	2.60	1.980
9.	Learning about mole concept is not necessary for my future.	60.3	30.0	1.70	5.00	3.00	1.480
10.	I sometimes dodge classes because the lesson is boring.	50.0	41.7	5.00	3.3	0.00	1.620

KEYS: SA=Strongly Agree, A=Agree, SDA=Strongly Disagree, D= Disagree, NS= Not Sure

Note: Strongly agree and agree were put together to represent agree whilst Strongly Disagree and Disagree were put together to represent Disagree.

The first item on Table 7 above sought students' views on whether mole concept was difficult to understand or not. About 67.7% of the respondents agreed to the statement that mole concept was difficult to understand, 29.1% disagreed whilst 3.2% were not sure. This indicates that majority of the students find it difficult to understand the mole concept.

Item two of Table 7 above elicited responses on whether mole concept was very interesting or not. The findings revealed that most of the respondents, that is 80.7%, disagreed to the statement with 16.2% agreeing and 3.1% not sure of themselves. Therefore, it can be concluded that most of the students did not find mole concept interesting to study.

Responses from item 3 on Table 7 indicates that 56.1% agreed to the statement that they disliked studying the mole concept whilst 48.4% disagreed to it. Hence it can be seen from the results clearly that majority of them disliked studying on the mole concept.

Item 4 on Table 7 was on the issue that mole concept was very confusing. 58.1% of the respondents agreed to the statement. 35.4% disagreed whilst 6.5% were not sure. This indicates that most students found mole concept very confusing.

Item 5 on Table 7 above indicates that 25.8% agreed that they enjoyed solving problems on mole concept, 67.6% disagreed to the statement whilst 6.6% were not sure. This shows that majority of the students do not enjoy solving problems on mole concept.

Results from item 6 on Table 7indicates that 35.6% of the respondents agreed that they understood the mole concept formulas, symbols and units easily, with 58%

representing the majority disagreeing and 6.4% not sure about themselves. From the responses above, it clearly shows that majority of the respondents found it difficult to understand the mole concept formulas, symbols and units.

Results from item 6 on Table 7 reveals that 39.1% agreed to liking the teachers teaching style with 48.1% disagreeing and 12.8% not sure. Hence from the findings above it clearly indicates that majority of the class disliked their teachers teaching style.

Findings from item 8 (Table 7) shows that 73.3% agreed to not understanding what their teacher teaches, 24.1% disagreed whilst 26.0% were not sure. It can be seen that many of them did not appreciate the teacher's method of teaching thus leading to them not understanding what their teacher teaches them.

Responses from item 9 (Table 7) indicates that 90.3% agreed that learning about mole concept is not necessary for their future, whilst 6.70% disagreed with 3.0% not sure. The findings above reveals that majority of the respondents did not see the importance of studying the mole concept which may be due to lack of understanding of the subject.

Responses from item 10 on Table 7 shows that 91.7% dodged classes because the lessons were boring, whilst 8.3% did not. Hence from the responses above it can be seen that students sometimes dodged classes because lessons were boring which could be that teachers did not use methods that made lessons interesting

Results from students' post-perception and attitude questionnaire is displayed on Table 8.

Table 8: Responses of Students Post-Perception and Attitude Questionnaire (POSAQ)

Number	Item	Responses					
		SA (%)	A (%)	SDA (%)	D (%)	NS (%)	Mean (%)
1.	Mole concept is very difficult to understand.	10.0	6.7	38.3	45.0	0.00	3.180
2.	Mole concept is very interesting.	31.7	44.3	11.5	6.20	6.30	1.880
3.	I dislike studying the mole concept.	2.10	31.2	31.7	30.0	3.00	1.700
4.	Mole concept is very confusing.	11.1	9.00	31.7	46.6	1.60	2.520
5.	I enjoy solving problems on the mole concept.	48.3	30.0	13.1	8.2	0.40	1.820
6.	Mole concept formulas, symbols and units are easy to understand.	33.3	28.0	21.7	15.0	2.00	2.220
7.	I like the teachers teaching style.	33.0	28.3	21.2	17.0	0.50	2.221
8.	I do not understand what the teacher teaches.	20.0	16.7	15.1	46.6	1.60	2.900
9.	Learning the mole concept is not necessary for my future.	5.00	30.0	1.70	60.3	3.00	3.005
10.	I sometimes dodge classes because the lesson is boring.	10.0	13.3	30.0	45.0	1.70	3.130

KEYS: SA=Strongly Agree, A=Agree, SDA=Strongly Disagree, D= Disagree, NS= Not Sure

Note: Strongly agree and agree were put together to represent agree whilst Strongly Disagree and Disagree were put together to represent Disagree.

The first item on Table 8 above sought students' views on whether mole concept was difficult to understand or not. 83.3% of the respondents agreed with the statement that mole concept was difficult to understand, 16.7% disagreed whilst 0% were not sure. This indicates that majority of the students did not find it difficult to understand the mole concept.

Item two of Table 8 above elicited responses on whether studying mole concept was very interesting or not. The findings revealed that most of the respondents that is 76.0% agreed to the statement with 17.7% disagreeing and 6.3 % not sure of themselves. Therefore, it can be concluded that most of the students found mole concept very interesting to study.

Responses from item 3 (Table 8) indicates that 33.3% agreed to the statement that they disliked studying the mole concept whilst 61.7% disagreed with only 5.0% not sure about themselves. Hence it can be seen from the results clearly that majority of the respondents liked studying the mole concept.

Item 4 on Table 8 was on the issue that mole concept was very confusing. 20.1% of the respondents agreed to the statement. 78.3% disagreed whilst 1.6 % were not sure. This indicates that most students did not find mole concept confusing.

Responses from item 5 (Table 8) indicates that 78.3% agreed that they enjoyed solving problems on the mole concept, 21.3% disagreed to the statement whilst 0.4% were not sure. This shows that a large number of the students enjoyed solving problems involving the mole concept.

Findings from item 6 (Table 8) revealed that 61.3% of the respondents understood the mole concept formulas, symbols and units easily, whilst 36.7% did not and 2.0% not sure about themselves. From the responses above, it clearly shows that majority of the respondents understood the formulas, symbols and units of the mole concept with ease.

Results for item 8 (Table 8) shows that 61.3% agreed to liking the teachers teaching style with 38.2% not liking and 0.50% not sure. Hence from the findings above it clearly indicates that majority of the class liked their teachers teaching style.

Findings from item 8 on Table 8 shows that 36.7% agreed to not understanding what the teacher teaches, 61.7% disagreed whilst 1.60% were not sure. It can be seen from the results that many of them appreciated the teacher's method of teaching thus leading them to understand what their teacher taught them.

Responses from item 9 on Table 8 indicates that 35.0% agreed that learning about the mole is not necessary for their future, whilst 62.0% disagreed with 3.0% not sure. The findings above reveals that majority of the respondents saw the necessity of studying about the mole.

Responses from item 10 on Table 8 shows that 23.3% dodged classes because the lessons were boring, whilst 75.0% did not with 1.70% not sure. Hence from the responses above it can be seen that most students did not dodge classes because lessons were not boring which could be that their teacher packaged the lessons very well to make it interesting.

Results from Table 7 revealed that many of the students had some negative perceptions and attitude towards mole concept which affected their performance. Therefore, the findings above are in line with the findings of Sadi and Cakiroglu's (2011) who found out that the method used to teach seemed to affect students' attitude toward the class, and this may be the factor that most influences learning .The findings from the post intervention questionnaire revealed that students now had a change of perception and attitude because most of them now liked the mole concept which indicates that they have gained more understanding hence the topic is no longer confusing but rather interesting. A study by Akkuzu and Akcay (2011) showed a relationship between students' attitude and their academic performance. They suggested that students' positive attraction toward certain kinds of teaching may help increase their academic performance. Eastman et al. (2011) suggest that when students have a positive perception and attitude toward something, they will do the task well.

However, the results of this study did not agree with those of Erdem (2012), who discovered that PBL had no influence on students' attitude toward science. Langen and Welsh (2006), also discovered that PBL had no influence on students' opinions of a biology course about the environment. Gurses et al.'s (2007) investigation into students' attitude toward chemistry also revealed no significant improvement using PBL. Tosun and Senocak (2013) recently discovered no connection between PBL and the attitude of prospective secondary school teachers

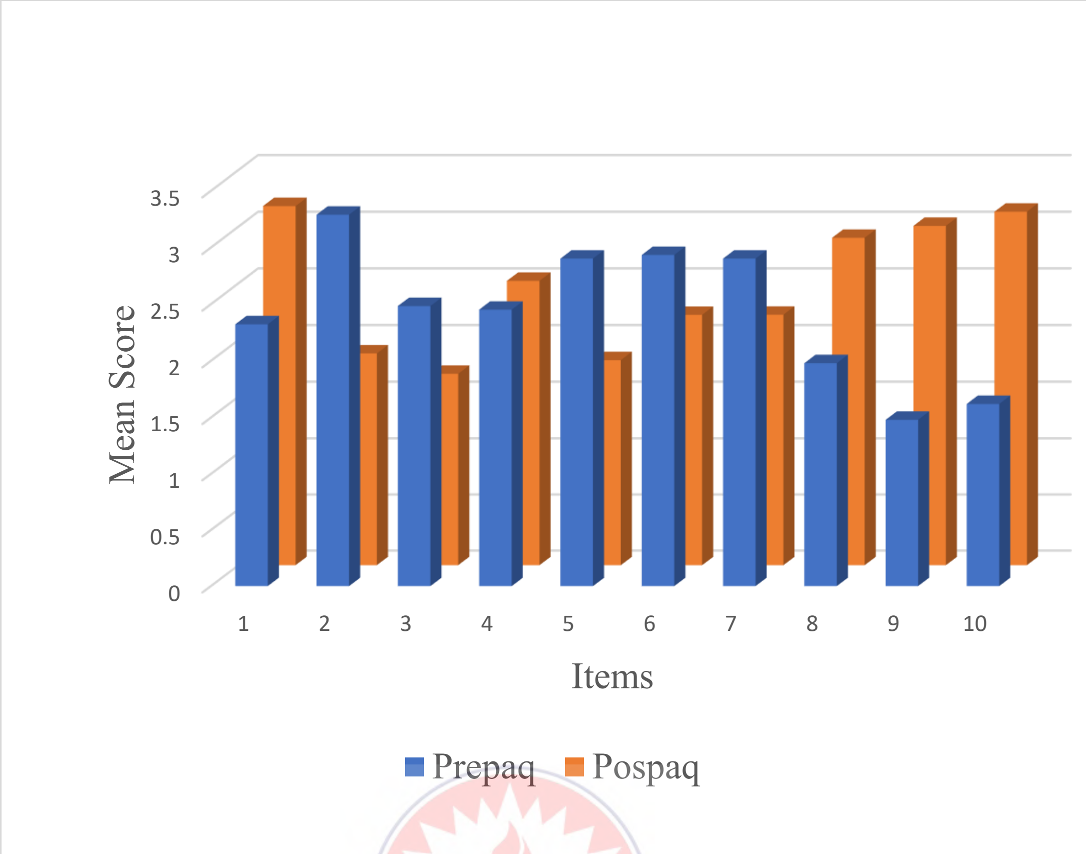


Fig 5: Comparism of the Means of the Pre and Post Perception Questionnaire

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings as well as conclusions of the study. It also contains recommendations for stakeholders, suggestion for further research and contributions of the study to science education.

5.1 Summary

The study was carried out in Obiri Yeboah SHS in the Assin North Municipality of the Central Region of Ghana using individual teacher action research approach. A total of 39 second year S.H.S general science students were conveniently selected for this study. The problem that prompted this study was the consistent poor performance of chemistry students of Obiri Yeboah Senior High on the mole concept especially when it comes to the application of the mole in solving quantitative problems. The purpose of this study therefore was to enhance academic performance of students in mole concept using problem-based learning instructional approach.

The study sought to find out whether the intervention used would help enhance the academic performance of students and also whether there was any significant difference between students' performance on mole concept before and after the intervention. It also investigated students 'perception and attitudes towards the mole concept before and after using problem-based learning instructional approach. The academic performance between male and female students on mole concept after being taught with the problem-based learning instructional approach was also compared to find out if there was any significant difference between them.

Two main instruments were used in this study, these were test items (pre and post) and questionnaires. A 5-point Likert-scale questionnaire (PREAQ and POSAQ), which consisted of 10 items, ranging from strongly agree to not sure was used to examine the attitudes of the students before and after using problem-based learning instructional approach in teaching the mole concept. The test items for the pre- and post-tests consisted of 15 closed multiple-choice test items and five essay questions selected from past questions from WAEC examinations as well as the researchers own developed questions. The findings from the study revealed that most of the students performed below average per the scores of the pre-test administered before the intervention.

The data collected was analyzed using quantitative approach. This approach included the use of percentages and descriptive statistics, such as the mean and the standard deviations. T-test statistic at a confidence level of 0.05 was used to find out whether there was any significant difference between students' scores before and after the intervention as well as between male and female students' academic performance. The mean score for the pre-test and post-test were 19.43 and 31.60 respectively with a mean difference of 12.17. This indicates that there had been an increase in students' performance after the intervention. Hence it can be concluded that students performed academically better after the intervention. After testing the hypothesis, it was observed that there was a significant difference between the pre- and post-test scores of the students at the level of 0.0021 ($p > 0.05$), therefore the null hypothesis was rejected. Thus, PBL improved students' conceptual understanding leading to higher performance in the post-test. It was also found out that there was no significant difference between the academic performance of males and females after the intervention at the level of 0.459($p > 0.05$).

The responses from the questionnaire indicated that students' perception and 'attitude towards the mole concept changed after the intervention because students no longer saw mole concept as difficult. This implies that the use of problem-based learning instructional approach in teaching the mole concept showed a positive change with regard to the performance of the students as well as their perception and attitude.

The following are the major findings obtained from the analysis of the data collected:

1. It was observed that the use of PBL enhanced the academic performance of students in mole concept.
2. It was also realized that there was a statistically significant difference between students' test scores before and after using problem-based learning instructional approach.
3. The findings also indicated that there was no statistically significant difference between gender in performance when taught mole concept using problem-based learning instructional approach.
4. The study also indicated that the general perception and attitude of the respondents towards the mole concept became positive after the intervention.

5.2 Conclusion

This study found out that problem-based learning instructional approach is an effective intervention for enhancing students understanding and performance in mole concept. This is because students performed very well in the post-test after the intervention and there was also a significant difference between their pre and post-test scores. There was also a positive change in students' perception and attitude towards the mole concept after the intervention. It was also found that there was no difference in performance between males and females after using problem-based learning instructional approach as such it is a good model that does not show any disparities between gender in their academic performance on the mole concept.

Problem based learning is an effective instructional approach because the groupwork which is an essential aspect of PBL helps develop learning communities in which students feel comfortable developing new ideas and raising questions about the material (Allen, Duch, & Groh, 1996). Groupwork also enhances communication skills and students' ability to manage group dynamics and is also interesting and motivating for students because they become actively involved in the work and are held accountable for their actions by group members. Also, the PBL instructional approach of learning makes the teacher to become co-learner, facilitator, guide and it also helps learners to obtain information to solve problems rather than being passive learners as in behavioral theory of learning. Lastly, the PBL instructional approach takes care of individual differences during teaching and learning especially gender and different ability groups.

This research therefore concludes that, problem-based learning should be used in teaching science concepts because it helps students to understand concepts better leading to higher academic performance as well as development of positive attitudes and does not also discriminate against gender. It can also be deduced from the study that, when the appropriate environment and teaching methods are used in teaching, it helps students to discover things on their own. Therefore, this study corresponds with Hung's (2008) claim that problem-based learning appears to be the most innovative instructional method conceived and implemented in education with the aim of enhancing students' application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills.

5.3 Recommendations

The following recommendations were made based on the findings of the study:

- The results from this study showed that there was no difference in performance between male and female students using the PBL intervention, hence it is recommended that science departments in Senior High Schools especially Obiri Yeboah SHS should always consider this method of learning so that no student is disadvantaged by using only the traditional method of teaching.
- Chemistry teachers in Obiri Yeboah SHS should be encouraged to use PBL in their classrooms, since it helps students to improve their academic performance. This will help to solve the problem of negative perception and attitudes as well as poor performance of students in internal and external examinations.
- The study revealed that learning in small groups was effective in enhancing students understanding. Thus, teachers should use group sizes based on their population size of their class during teaching and learning. For example, six or five students to a group in large classes and four or three students to a group of relatively small classes.

5.4 Suggestions for further Research

- This study was carried out at Obiri Yeboah SHS in Assin Foso, thus there is the need for it to be replicated in all SHS in the country so as to measure the effect of problem-based learning instructional approach on students' academic performance in mole concept.

- There is the need for further studies into the impact of problem-based learning on the teaching and learning of chemistry and science in in general.
- Teachers play an important role in the development of their students; therefore, other researchers could also consider assessing the perception and attitude of pre service teachers in Ghana towards the use of PBL in teaching the mole concept.
- Other researchers can replicate this study with a larger sample and a longer period to ascertain the effect of PBL on students' performance.

REFERENCES

Abdalla, M. (1991). *An evaluation of first year practical chemistry in Jordanian University State* [Doctoral dissertation, University of East Anglia]. Dissertation Abstract International.

AbdulRaheem, Y., Yusuf, H. T., & Odutayo, A. O. (2017). Effect of peer tutoring on students' academic performance in economics in Ilorin South, Nigeria. *Journal of Peer Learning*, *10*(1), 95-102. https://ro.uow. edu.au/ ajpl/ vol10 /iss1/7

Abend, G. (2008). The meaning of 'theory'. *Sociological Theory*, *26*(2), 173-199.

Adamu, I. M. (2011). *Effects of demonstrating teaching strategy in remedying misconceptions in organic chemistry among students of college education in Kano State* [Unpublished M.Ed. (Sci Edu) Thesis]. Ahmadu Bello University, Zaria.

Adeleke, M. A. (2007). Gender disparity in mathematical performance revisited: Can training in problem solving bring difference between boys and girls? *Essays in Education Online Journal, 21*(1), 1. http/www.usca.edu/Essays.

Adigun, J., Onihunwa, J., Irunokhai, E., Sada, Y., & Adesina, O. (2015). Effect of gender on students' academic performance in computer studies in secondary schools in New Bussa, Borgu Local Government of Niger State. *Journal of Education and Practice*, *6*(33), 1-7.

Afolabi, F., & Akinbobola, A. O. (2009). Constructivist problem-based learning technique and the academic achievement of physics students with low ability level in Nigerian secondary schools. *International Journal of Physics and Chemistry Education*, *1*(1), 45-51.

Agogo, P. O., & Otor, E. E. (2013). *Basic issues in the chemistry of matter*. Optimism Press.

Aidoo, B., Boateng, S. K., Kissi, P. S., & Ofori, I. (2016). Effect of problem-based learning on students' achievement in chemistry. *Journal of Education and Practice*, *7*(33), 103-108.

Akar, E. (2005). *Effectiveness of 5E learning cycle model on students' understanding of acid-base concepts* [Master's thesis, Middle East Technical University].

Akinbobola, A. O. (2006). *Effects of teaching methods and study habits on students' achievement in senior secondary school physics, using a pictorial organizer* [Unpublished Ph. D dissertation]. University of Uyo, Uyo, Nigeria.

Akinbobola, A. O. (2008). Facilitating Nigerian physics students' attitude towards the concept of heat energy. *Scientia Paedagogica Experimentalis*, *45*(2), 353.

Akkuzu, N., & Akcay, H. (2011). An effective model to increase student attitude and achievement: Narrative including analogies. *US-China Education Review A,5* ,612-623.

Aljohani, M. (2017). Principles of "constructivism" in foreign language teaching. *Journal of Literature and Art Studies*, *7*(1), 97-107.

Allen, D. E., Duch, B. J., & Groh, S. E. (1996). The power of problem-based learning in teaching introductory science courses. *New Directions for Teaching and Learning*, *68*, 43-52.

Ameh, P. O., & Dantani, Y. S. (2012). Effects of lecture and demonstration methods on the academic achievement of students in chemistry in Nassarawa Local Government Area of Kano State. *International Journal of Modern Social Sciences*, *1*(1), 29-37.

Armington, T. C. (2003). Environmental barriers to student success. *NADE Best practices in developmental mathematics* (2nd ed.).

Ary, D., Jacobs, L. C., & Razavieh, A. (*2002*). *Introduction to research in education.* Wadsworth/Thomson Learning.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* Freeman.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*(3), 586.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching andLlearning*,*68*, 3-12.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education* (Vol. 1). Springer Publishing Company.

Beller, M., & Gafni, N. (2002). The international assessment of educational progress in mathematics and sciences: The gender difference perspective. *Journal of Educational Psychology, 88* (2), 365 – 377.

Bell, R. L., Quazi, R., & Jasper, J. (2004). Mixed method instruction across business disciplines. *Southwestern Business Administration Journal, 4*(4), 35-47.

Belt, S. T., Evans, E. H., McCreedy, T., Overton, T. L., & Summerfield, S. (2002). A problem-based learning approach to analytical and applied chemistry. *University Chemistry Education*, *6*(2), 65-72.

Beong, C. (2016). *The use of activity method to enhance students' understanding of the mole concept in chemistry: A case study at Zamse senior high/technical school* [Unpublished undergraduate degree]. University of Education, Winneba, Ghana.

Bhandari, P., & Nikolopoulou, K. (2022). *What Is a Likert Scale? | Guide & Examples*. Scribbr. https://www.scribbr.com/methodology/likert-scale/

Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project-based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics Science and Technology Education*, *11*(3).

Brandon, A. F., & All, A. C. (2010). Constructivism theory analysis and application to curricula. *Nursing Education Perspectives*, *31*(2), 89-92.

Bridges, E. M., & Hallinger, P. (1996). Problem-based learning in leadership education. *New Directions for Teaching and Learning*, *1996*(68), 53-61.

Brinkley, K. (2011). *Teaching through problem-based learning*. Tennessee Teaching and Learning centre. http://tenntlc.utk.edu/files /2010/12/How ToPBL final. pdf.

Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. Association for Supervision and Curriculum Development. https://www.ascd.org/

Brody, M. (2006). The development of mathematics teaching and learning process: An application of action research. Montana State University, faculty. *http:// arexpedi tions montana. edu/index. Php*.

Brown, K. L. (2003). From teacher-centred to learner-centred curriculum: Improving learning in diverse classrooms. *Education*, *124*(1), 49-54.

Bunkure, Y. I. (2007). *Effects of computer assisted instruction on students' academic achievement in physics among NCE II students in Kano State* [Unpublished M. Ed. (Science Education) Thesis]. Ahmadu Bello University, Zaria.

Burmeister, M., & Eilks, I. (2012). An example of learning about plastics and their evaluation as a contribution to Education for Sustainable Development in secondary school chemistry teaching. *Chemistry Education Research and Practice*, *13*(2), 93-102.

Capon, N., & Kuhn, D. (2004). What's so good about problem-based learning? *Cognition and Instruction*, *22*(1), 61-79.

Cheaney, J. D., & Ingebritsen, T. (2005). Problem-based learning in an online course: A case study. *The International Review of Research in Open and Distributed Learning*, *6*(3).

Childs, P. E., & Sheehan, M. (2009). What's difficult about chemistry? An Irish perspective. *Chemistry Education Research and Practice*, *10*(3), 204-218.

Chiu, M. H. (2005). A national survey of students' conceptions in chemistry in Taiwan. *Chemistry Educational International*, *6* (1).

Conway, J., & Little, P. (2000). From practice to theory: Reconceptualising curriculum development for problem-based learning. *Problem-based learning: Educational innovation across disciplines. Selected papers from the Second Asia-Pacific Conference on problem-based learning, Singapore, 169, 79.*

Copple, C., & Bredekamp, S. (2009). *Developmentally appropriate practice in early childhood programs serving children from birth through age 8*. National Association for the Education of Young Children.

Creswell, J. W. (2009). Mapping the field of mixed methods research. *Journal of Mixed Methods Research*, *3*(2), 95-108.

Çuhadaroğlu, F., Karaduman, A., Önderoğlu, S., Karademir, N., & Şekerel, B. (2003). *Problem-based learning sessions implementation guide*. Hacettepe University, Department of Medical Education and Informatics, Ankara.

Dağyar, M., & Demirel, M. (2015). Effects of problem-based learning on academic achievement: A Meta-Analysis Study. *Education and Science*, 40(181), 139-174. https://doi.org/10.15390/EB.2015.4429

Dahsah, C., & Coll, R. K. (2007). Thai Grade 10 and 11 students' conceptual understanding and ability to solve stoichiometry problems. *Research in Science & Technological Education*, *25*(2), 227-241.

Dalfaro, N.A., Del Valle, C.G., & Aguilar, N.F. (2017). The application of problem-based learning in engineering careers. *1st. Latin American Engineering Congress* (pp.13-15). Entre Ríos.

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, B., & Sumara, D. (2002). Constructivist discourses and the field of education: Problems and possibilities. *Educational Theory*, *52*(4), 409.

Degraffs, E., & Kolmos. A. (2007). *Management of change: Implementation of problem based and project learning in engineering*. Sense Publishers.

Deshmukh, N. D., & Deshmuhk, V. M. (2009). *TextBook : A source of students misconception at the seconday school Level.* Homi Bhabha Centre For Science Education ,TIFR .

Dikmenli, M., & Cardak, O. (2008). A Study on misconceptions in the 9th Grade High Schools Biology Textbooks. *Eurasian Journal of Educational Research*, 17,130-141.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction*, *13*(5), 533-568.

Dori, Y. J., & Hameiri, M. (1998). The 'mole environment' study ware: Applying multidimensional analysis to quantitative chemistry problems. *International Journal of Science Education*, *20*(3), 317-333.

Driscoll, M. (2000). *Psychology of learning for instruction*. Allyn & Bacon.

Duch, B. J. (2001). Writing problems for deeper understanding. In B. J. Duch, S. E. Groh, & D. E. Allen (Eds.), *The power of problem-based learning* (pp. 59-68). Sterlin.

Dudovskiy, J. (2022). An ultimate guide to writing a dissertation in business studies: A step-by-step assistance. *Journal of Mixed Methods Research, 4*(1) 6-16.

Duffy, T. M., & Jonassen, D. H. (1991). Constructivism: New implications for instructional technology? *Educational Technology*, *31*(5), 7-12.

Dusick, D. M. (2011). *Writing the delimitations*. http://bold-ed.com /delimi tations .htm

Easterby-Smith, M., Thrope, R., & Lowe, A. (1991). *Management Research: An introduction.* Sage Publications.

Eastman, J. K., Iyer, R., & Eastman, K. L. (2011). Business students' perceptions, attitudes, and satisfaction with interactive technology: An exploratory study. *Journal of Education for Business*, *86*(1), 36-43.

Eggen, P., & Kauchak, D. (2001). *Educational psychology: Windows on classrooms.* Prentice Hall.

Ehindero, O. J., Adeleke, M. A., Oloyede, E. O. & Ajibade, Y.A. (2009). Looking at gender disparity in science and mathematics from other angles: Are there differences in logical reasoning and linguistic abilities? *African Journal of Educational Studies in Mathematics and Science, 7*(3), 35-43.

El Miedany, Y., & El Miedany, Y. (2019). Teaching: Art or Science? *Rheumatology teaching: The art and science of medical education*, (pp. 3-8).

Elliott, J. (1994). Research on teachers' knowledge and action research. *Educational Action Research*, *2*(1), 133-137.

Elliott, S. N., Kratochwill, T. R., Littlefield Cook, J. & Travers, J. (2000). *Educational psychology: Effective teaching, effective learning* (3rd ed.). McGraw-Hill.

Erdem, E. (2012). Examination of the effects of project-based learning approach on students' attitudes towards chemistry and test anxiety. *World Applied Sciences Journal*, *17*(6), 764-769.

Evensen, D. H., & Hmelo, C. E. (2001). *Problem-based learning: A research perspective on learning interaction.* Lawrence Erlbaum Associates.

Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centred instruction. *College Teaching*, *44*(2), 43-47.

Feldman, A. (2002). Existential approaches to action research. *Educational Action Research, 10*(2), 233-252.

Ferrance, E. (2000). *Themes in education: Action research*. Northeast and Islands Regional Educational Laboratory.

Festus, C. (2007). *Towards Effective learning for learners.* Tower Gate Resources.

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice*. Teachers College Press.

Fox, R. (2001). Constructivism examined. *Oxford Review of Education*, *27*(1), 23-35.

Gallagher, S. A. (1997). Problem-based learning: Where did it come from, what does it do, and where is it going? *Journal for the Education of the Gifted*, *20*(4), 332-362.

Gamoran, A., Secada, W. G., & Marrett, C. B. (2000). The organizational context of teaching and learning: Changing theoretical perspectives. *Handbook of the sociology of education* (pp. 37-63). Springer.

Ghufron, M. A., & Ermawati, S. (2018). The strengths and weaknesses of cooperative learning and problem-based learning in EFL writing class: Teachers' and students' perspectives. *International Journal of Instruction*, *11*(4), 657-672.

Gillies, R. M. (2006). Teachers' and students' verbal behaviours during cooperative and small-group learning. *British Journal of Educational Psychology, 76*(2), 271-287.

Goldhaber, D. E. (2000). *Theories of human development : Interactive perspective.* Mountain View.

Gonen, S., & Kocakaya, S. (2010). A physics lesson designed according to 7E model with the help of instructional technology (Lesson Plan). *Turkish Online Journal of Distance Education*, *11*(1), 98-113.

Gorski, P. C. (2006) *Teacher Action Research*. http://www.edchange.org/ multicult-ural/tar/illustration.html.

Gupta, K. (2011). *A practical guide to needs assessment*. John Wiley & Sons.

Gürses, A., Açıkyıldız, M., Doğar, Ç., & Sözbilir, M. (2007). An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course. *Research in Science & Technological Education*, *25*(1), 99-113.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education*, *20*(3), 261-273.

Hare, D., Howard, E., & Pope, M. (2005). Enhancing technology using student teaching: A case study. *Journal of Technology and Teacher Education, 13*(4), 573-618.

Hasna, F. (2009). Nursing information systems in Jordan. *International Journal of Nursing Practice*, *15*(2), 69-73.

Hawkins, D. I., Best, R. J., & Coney, K. A. (2004). Customer Behaviour: Building Marketing Strategy. McGraw-Hill.

Hendry, G. D., Cumming, R. G., Lyon, P. M., & Gordon, J. (2001). Student-centred course evaluation in a four-year, problem based medical programme: Issues in collection and management of feedback. *Assessment & Evaluation in Higher Education*, *26*(4), 327-339.

Hmelo, C.E., Gotterer, G.S. & Bransford, J.D. (1997). A theory-driven approach to assessing the cognitive effects of PBL. *Instructional Science*, 25, 387-408.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review*, *16*(3), 235–266.

Hmelo-Silver, C. E., & Ferrari, M. (1997). The problem-based learning tutorial: Cultivating higher order thinking skills. *Journal for the Education of the Gifted, 2*0(4), 401–422.

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education: A pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. *International Journal of Science and Mathematics Education*, *9*(6), 1459-1483.

Holt, D. G., & Willard-Holt, C. (2000). Let's get real: Students finding authentic corporate problems. *Educational Technology Research and Development*, *45*(1), 65-94.

Honebein, P. C. (1996). Seven goals for the design of constructivist learning environments. *Constructivist learning environments: Case studies in instructional design* (pp. 11-24).

Hung, W. (2008). The 9-step problem design process for problem-based learning: Application of the 3C3R model. *Educational Research Review*, *4*(2), 118-141.

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. *Handbook of Research on Educational Communications and Technology*, *3*(1), 485-506.

Hwang, W. C. (2004). *The types and causes of misconceptions of elementary students on acids–bases.* Annual Report to the National Science Council in Taiwan (in Chinese). Taiwan: National Science Council.

Ifemuyinwa, G. L. (2008). Notes on effective methods of teaching preliminary tests in qualitative analysis in senior secondary schools. Effective methods of teaching chemistry practical. *A handbook for chemistry teachers by science teachers' association of Nigeria (pp. 34- 36)*.

Ifemuyiwa, S. A., & Ajilogba, I. S. (2012). A problem-solving model as a strategy for improving secondary school students' achievement and retention in further mathematics. ARPN Journal of Science and Technology, 2(2), 128.

Indriyanti, N. Y. (2016). *The mole concept: Students' misconceptions, difficulties and the challenge*. Schüling Verlag.

Indriyanti, N. Y., & Barke, H. D. (2017, August). Teaching the mole concept with sub-micro level: Do the students perform better? In *AIP Conference Proceedings* (Vol. 1868, No. 1). AIP Publishing.

Jensen, W. B. (2004). The origin of the mole concept. *Journal of Chemical Education*, *81*(10), 1409.

Jimoh, S. B., & Fatokun, K. V. F. (2020). Effect of problem-based learning strategy on chemistry students' achievement and interest in mole concept in Federal Capital Territory, Abuja. *Anchor University Journal of Science and Technology*, *1*(1), 136-143.

Jobber, J. 2004. *Principles and practice of marketing* (41st ed). McGraw-Hill.

Jonassen, D. (1999). Designing constructivist learning environments. In C. Reigeluth (Ed.), *Instructional design theory and models*: *A new paradigm of instructional theory (pp.215-239*). Lawrence Erlbaum Associates.

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development, 39* (3), 5-14.

Kartubi, A. (2017). *The correlation between students 'attitude towards English and their English proficiency of the eleventh rade students of sma n 1 pangkalan lampam* [Doctoral dissertation, UIN Raden Fatah Palembang].

Kemmis, S.; McTaggart, R. (1988). *The action research planner.* Deakin University Press.

King, M. (2004). *Lecture notes.* Teaching science in English.The University of Sydney.

Kinney, D.P., & Robertson, D. E (2003). Technology makes possible new models for delivering developmental mathematics instruction. *Mathematics and Computerized Education, 37(3), 315-328.*

Kirk, J, & Miller, M. L. (1999). *Reliability and validity in qualitative research*. Sage.

Koballa, T. R., & Glynn, S. M. (2007). Attitudinal and motivational constructs. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education.* Erlbaum.

Lagowski, J. J. (1990). Reetention rates for students learning. *Journal of Chemical Education*, 67, 811-812.

Lakpini, M. A. (2006). *Effect of conceptual change and instructional strategy on the achievement, retention and attitude of secondary school biology students with varied ability* [Unpublished Ph.D Dissertatio].Ahmadu Bello University , Zaria.

Langen, T. A., & Welsh, R. (2006). Effects of a problem-based learning approach on attitude change and science and policy content knowledge. *Conservation Biology*, *20*(3), 600-608.

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].

Lee, W. A. (2004). *A study on causes of elementary school students misconception in oxidation-reduction*. Annual Report to the National Science Council in Taiwan.

Littleton, K., Wood, C., & Chera, P. (2006). Interactions with talking books: Phonological awareness affects boys' use of talking books. *Journal of Computer Assisted Learning*, *22*(5), 382-390.

Lomax, R. G., & Hahs-Vaughn, D. L. (2013). *An introduction to statistical concepts*. Routledge.

Mahmood, S. (2006). *Evaluating the mathematics performance of developmental mathematics students when computed assisted instruction is combined with traditional strategies* (Publication No. AAT 3251891) [Doctoral dissertation, Ed. D. dissertation, Texas South University, Texas]. Dissertation & Thesis: Full Text Manuscript submitted for publication.

Mapotse, T. A. (Ed.). (2017). *Cross-Disciplinary approaches to action research and action learning*. IGI Global.

Mc Collister, J. (2014). *Action research in education: Methods and examples*. Progressive Academic Publishing.

McCombes, S. (2019). *Research Design: Types, Methods, and Examples*. Scribbr. https://www.scribbr.com/statistics/descriptive-statistics/

McDermott, L. C., & Shaffer, P. S. (1992). Research as a guide for curriculum development: An example from introductory electricity. Part I: Investigation of student understanding. *American Journal of Physics*, *60*(11), 994-1003.

McLeod, S. (2018). Questionnaire: Definition, examples, design and types. *Simply Psychology*, *78*, 350-365.

Merriam, S. B., & Caffarella, R. S. (1999). *Learning in adulthood: A comprehensive guide* (2nd ed.). Jossey-Bass.

Meyer, J. (2000). Using qualitative methods in health-related action research. *British Medical Journal*, *320*(7228), 178-181.

Miller P. (2001). Learning styles: The multimedia of the mind. *Education Resources Information Centre, 451,* 140.

Miller, C. A. (2007). *Action research: Making sense of data.* *www.coe.fau.edu/sfcel/sensdata.htm*.

Millis, B. J. (2002). Fulfilling the promise of the "seven principles" through cooperative learning: Action agenda for the University classroom. *Journal on Excellence in College Teaching,* 2, 139-144.

Mills, G. E. (2003). *Action research: A guide for the teacher researcher.* Merrill/Prentice Hall.

Ministry of Education. (2010). *Teaching syllabus for Chemistry: Senior high school ,1-3*. Accra, Ghana.

Moss, K., & Pabari, A. (2010). The mole misunderstood. *New Directions in the Teaching of Natural Sciences*, (6), 77-86. https://doi.org /10.29311 /ndtps. v0i6.392.

Noordin, M. K., Nasir, A. N., Ali, D. F., & Nordin, M. S. (2011). Problem-based learning (PBL) and project-based learning (PjBL) in engineering education: A comparison. *Proceedings of the IETEC*, *11*.

Noviani, R. (2020). *The language attitude of students toward English Language Learning: A survey of six junior high schools in Palembang* [Doctoral dissertation, UIN Raden Fatah Palembang].https://doi.org/ 10.1021/ ed053p720.

Oliver, K. M. (2000). Methods for developing constructivist learning on the web. *Educational Technology*, *40*(6), 5-18.

Omwirhiren, E. M., & Anderson, F. E. (2016). Effect of class size and students' attitude on academic performance in chemistry at demonstration secondary school, Ahmadu Bello University Zaria, Nigeria. *IOSR Journal of Research & Method in Education*, *6*(1), 1-6. 5.

Oni, S. (2012). *Revitalizing Nigerian education in digital age.* Trafford Publishing.

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* (pp.227-251). Kluwer.

Page-Bucci, H. (2003). The value of Likert scales in measuring attitudes of online learners. *HKA Designs.* http://www.hkadesibns. co.uk/websites /msc/reme /likert.htm.

Parsons, R. D., & Brown, K. S. (2002). *Teacher as reflective practitioner and action researcher*. Wadsworth/Thomson Learning.

Pease, M. A., & Kuhn, D. (2010). Experimental analysis of the effective components of problem-based learning. *Science Education*, *95*(1), 58 – 86.

Pekdağ, B., & Azizoğlu, N. (2013). Semantic mistakes and didactic difficulties in teaching the "amount of substance" concept: A useful model. *Chemistry Education Research and Practice*, *14*(1), 117-129.

Perrealt, Jr. E. & McCarthy, J. (2005). *Basic marketing: A global managerial approach*. McGraw-Hill.

Rahi, S. (2017). Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics & Management Sciences*, *6*(2), 1-5.

Ramayah, M., Sivanandan, P., Nasrijal, N. H., Letchumanan, T., Leong, L. C., & Ramayah, M. (2009). Preferred learning style: Gender influence on preferred learning style among business students. *Journal of US-China Public Administration*, *6*(4), 65-78.

Reynolds, F. (1997). Studying psychology at degree level: Would problem-based learning enhance students' experiences? *Studies in Higher Education*, *22*(3), 263-275.

Rodríguez González, C. A., & Fernández Batanero, J. M. (2016). A review of problem-based learning applied to engineering. *EduRe Journal: International Journal on Advances in Education Research, 3 (1), 14-31*.

Rodríguez, C. A., & Fernández Batanero, J. M. (2017). Application of problem-based learning in university students of irrigation engineering. *Journal of Science Education, 18 (2), 90-96.*

Rovai, A. P. (2004). A constructivist approach to online college learning. *The Internet and Higher Education*, *7*(2), 79-93.

Sadi, Ö., & Cakiroglu, J. (2011). Effects of hands-on activity enriched instruction on students' achievement and attitude toward science. *Journal of Baltic Science Education*, 10(2), 87-97.

Sani, L. (2010). *Misconceptions of inorganic chemistry among senior secondary chemistry students of Zaria* Metropolis [Unpublished B.sc(Ed.) Project] Ahmadu Bello University, Zaria.

Santrock, J. W. (2003). *Psychology: Essentials*. McGraw-Hill.

Savery, J. R. & Duffy, T. M. (1995). Problem-based learning: An instructional model and its constructivist framework. *Educational Technology*, 35 (5), 31-37.

Sawyer, J. F.A., Simpson, J. M. Y. & Asher, R.A., (2001). *Concise encyclopedia of language and religion*. Elsevier Science http://repositoryradenfatah. ac.id/78 09/2/skripsi%

Scholkmann, A. (2016). Inquiry-discovery learning: Rediscovery of a didactic principle. *New Handbook of University Teaching NHL (pp. 1-36).* DUZ publishing and media house.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*(7), 749-752.

Sharma, B. (2018). Processing of data and analysis. *Biostatistics and Epidemiology International Journal*, *1*(1), 3-5.

Soyibo, K. (2008). A review of some sources of students' misconception in biology. *Singapore Journal of Education*, 15, 1-11.

Sridevi, K. V. (2008). *Constructivism in science education*. Discovery Publishing House.

Stringer, E. T. (1999). *Action Research* (2nd ed). Sage Publications.

Strobel, J., & Van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-based Learning*, *3*(1), 44-58.

Taber, K. S. (2019). The challenge of teaching and learning chemical concepts. *The nature of the chemical concept: Re-constructing chemical knowledge in teaching and learning*, 1-13.

Tam, M. (2000). Constructivism, instructional design, and technology: Implications for transforming distance learning. *Journal of Educational Technology & Society*, *3*(2), 50-60.

Tan O.S. (2003). *Problem-based learning innovation: Using problems to power learning in the 21st century.* Thomson Learning.

Tchudi, S. & Lafer, S. (1996). *The interdisciplinary teacher's handbook: Integrated teaching across the curriculum*. Boynton/Cook.

Teaching Guide for GSIs. Learning: Theory and Research (2015). http://gsi. Berkeley .edu/media/Learning.pdf

Theofanidis, D., & Fountouki, A. (2019). Limitations and delimitations in the research process. Periopera-tive nursing (GORNA), 7(3), 155–162. http://doi.org/10.5281/+zenodo.2552022.

Tosun, C., & Senocak, E. (2013). The effects of problem-based learning on metacognitive awareness and attitudes toward chemistry of prospective teachers with different academic backgrounds. *Australian Journal of Teacher Education*, *38*(3), 61-73.

Toulmin, S.E. (1972). *Human understanding: Collective use and understanding of concepts*. Princeton University Press.

Ünal, E., & İşeri, K. (2012). Analysis of the relationship between reading and writing attitudes of teacher candidates and their academic achievements through the structural equation model. *Ilkogretim Online*, *11*(4).

Von Glasersfeld, E. (1974). Piaget and the radical constructivist epistemology. *Epistemology and Education*, *1*, 24.

Vorsah, R. E., & Adu-Gyamfi, K. (2021). High school chemistry teachers' perspectives and practices on teaching mole concept. *European Journal of Education Studies*, *8*(2).

Voska, K. W., & Heikkinen, H. W. (2000). Identification and analysis of student conceptions used to solve chemical equilibrium problems. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *37*(2), 160-176.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological process.* Harvard University Press.

Walker, A., & Leary, H. (2009). A problem-based learning work? A meta-analysis: Differences across problem types, implementation types, disciplines, and assessment levels. *Interdisciplinary Journal of Problem-based Learning*, 3(1), 12–43. https://doi.org/ 10.7771/1541-5015.1061.

Ward, H. W. & Stoker, M. M. (1996*). Achievement and ability tests-definition of the domain: Educational measurement* (2nd ed.) University press of America.

Watson, B. & Kopnicek, R. (1990). Teaching for conceptual change: Confronting children's experiences. *Phi Delta Kappan, 71*(9), 680-684.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, *32*(4), 387-398.

Weldy, T. G., & Turnipseed, D. L. (2010). Assessing and improving learning in business schools: Direct and indirect measures of learning. *Journal of Education for Business*, 85(5), 268-273.

Wieser, M. E. (2006). Atomic weights of the elements 2005 (IUPAC Technical Report). *Pure and Applied Chemistry*, *78*(11), 2051-2066.

Wilson, B., & Cole, P. (1991). A review of cognitive teaching models. *Educational Technology Research and Development*, 39 (4), 47–64.

Yaayin, B. (2016). *Effect of problem-based learning on students' achievement in mole concept: A case study at Tamale College of Education* [Master's Thesis, University of Education, Winneba].

APPENDIX A

OBIRI YEBOAH SENIOR HIGH SCHOOL

MOLE CONCEPT PRE- TEST

This questionnaire aims to find out your basic knowledge about mole concept. Please respond to each item to the best of your knowledge.

NAME……………………………………… CLASS……… TIME: 1HR 30MINS

Section A: Objectives (Choose the correct answer)

1. An aqueous solution of sodium hydroxide containing 2g in 200 cm^3 of solution has a concentration of [NaOH = 40].

   a. $moldm^{-3}$ b. 0.005 $moldm^{-3}$ c. 0.25 $moldm^{-3}$ d. 0.40 $moldm^{-3}$

2. What mass of Na_2CO_3 would be required to prepare 250 cm^{-3} of 0.15 $moldm^{-3}$ solution? [Na_2CO_3 = 106]

   a. 3.98g b. 13.25g c. 15.90g d. 63.60g

3. How many NO_3^- ions are contained in 0.10 $moldm^{-3}$ $Ca(NO_3)_2$ solution? ($L = 6.02 \times 10^{23}$ mol^{-1})

   a. 1.204×10^{22} b. 1.204×10^{23} c. 12.04×10^{22} d. 12.04×10^{23}

4. Which of the following compounds has the least relative molecular mass? [H = 1.0 C =12 O = 16 P = 31]

   a. H_2CO_3 b. H_2SO_4 c. H_3PO_4 d. HCOOH

5. What volume will 11.0g of carbon (IV) oxide occupy at standard temperature and Pressure (s.t.p)? [CO_2 = 44, Molar Volume of a gas at s.t.p = 22.4 dm^3]

   a. 0.056 dm^3 b. 0.56 dm c. 5.6 dm^3 d. 56.0 dm^3

6. Calculate the relative molecular mass of $(NH_4)_2$ $SO_4.FeSO_4.6H_2O$.

   [H = 1.0 N = 14.0 O = 16.0 S = 32.0 Fe = 56.0]

a. 296 b. 312 c. 374 d. 392

7. How many moles of hydrogen atoms are in 49.0 g of H_2SO_4? [H = 1, O = 16, S = 32]

a. 0.2 b. 0.4 c. 1.0 d. 2.0

8. A vessel contains 1.6 moles of oxygen gas. Calculate the number of molecules of the gas. [Avogadro's constant = 6.02×10^{23} mol^{-1}]

a. 3.76×10^{23} b. 9.64×10^{23} c. 19.30×10^{23} d. 12.10×10^{23}

9. Calculate the number of moles of sodium hydroxide in 25 mol dm^{-3} of its solution.

a. 0.0125 moles b. 0.1250 moles c. 1.2500 moles d. 12.500 moles

10. What volume of 0.20 $moldm^{-3}$ solution of NaOH would yield 5g of solid NaOH On evaporation? [NaOH = 40 g mol^{-1}]

a. 600 cm^3 b. 625 cm^3 c. 1000 cm^3 d. 1600 cm^3

11. A 250 cm^3 solution contains 14.63 g of a salt. Calculate the concentration of the solution in mol dm^{-3} given that the formula mass of the salt is 58.5 g mol^{-1}.

a. 0.063 $moldm^{-3}$ b. 0.63 $moldm^{-3}$ c. 0.25 $moldm^{-3}$ d. 1.00 $moldm^{-3}$

12. Which of the following groups of substances has the same number of moles?

a. 8 g of Mg; 8 g of Al; 36 g of K b. 12 g of Mg; 24 g of Al; 36 g of K

c. 2.4 g of Mg; 2.7 g of Al: 3.9 g of K d. 1.6 g of Mg; 0.9 g of Al; 1.3 g of K

13. A gas of mass 0.358 g occupies a volume of 400 cm^3 at s.t.p. What is its relative molar mass? [1 mole of a gas occupies 22.40 dm^3 at s.t.p]

a. 10 b. 20 c. 28 d. 56

14. The number of entities in one mole of a substance is known as

a. Atomicity b. Avogadro's number c. Basicity d. Quantum number

15. What is the amount of potassium hydroxide in 250 cm^{-3} of 0.05 mol dm^{-3} of its solution?

 a. 0.0125 moles b. 0.1250 moles c. 1.2500 moles d. 12.5000 moles

Section B (Essay)

Attempt all questions

1. What volume of 0.30 M H_2SO_4 would contain 1.35 g H_2SO_4?
2. An amount of 0.25 g of aspirin, $C_9H_8O_4$, is contained in 100 cm^3 of a solution. How many moles and how many molecules of aspirin are in 1.0 dm^3 of the solution?
3. A gas X_2O_3 occupied a volume of 5.6dm^3 at s.t.p. Calculate the molar mass and hence the atomic mass of X if the mass of the gas was found to be 16g.
4. Powdered aluminium reacts with iron (III) oxide to produce aluminium oxide and molten iron. What mass of aluminium oxide is produced when 2.3g of Aluminium reacts with iron (III) oxide? The equation for the reaction is: $2Al_{(g)} + Fe_2O_{3(s)} \rightarrow 2Fe_{(s)} + Al_2O_{3(s)}$.
5. 36g of $CaCO_3$ is dissolved in 300 cm^3 of water. What is its concentration in (i) $moldm^{-3}$ (ii) gdm^{-3}.

 [L= 6.02×10^{23}, C=12, H=1, O=16, Al=27, Ca=40, S=32]

APPENDIX B

OBIRI YEBOAH SENIOR HIGH SCHOOL

MOLE CONCEPT POST- TEST

NAME...CLASS..............   TIME: 1HR 30MINS

Section A: Objectives (Choose the correct answer)

1. The volume occupied by 0.02 moles of a gas at s.t.p. is

   a. 0.112 dm^3 b. 0.224 dm^3 c. 0.24 dm^3 d. 0.448 dm^3

2. The Avogadro number of particles (L) is 6.02×10^{23}. This means that the number of atoms in a 3g sample of ^{24}Mg is

   a. 7.53×10^{22} b. 1.51×10^{23} c. 2.41×10^{24} d. 4.82×10^{24}

3. Calculate the number of moles of sodium hydroxide in 25 cm^3 of 0.5 mol dm^{-3} of its solution.

   a. 0.0125 mol   b. 0.125 mol   c. 1.25 mol   d. 12.5 mol

4. A 200 cm^3 solution contains 14.63 g of a salt. Calculate the concentration of the solution in $moldm^{-3}$ if the formula mass of the salt is 58.5 g mol^{-1}.

   a. 0.063 $moldm^{-3}$ b. 0.63 $moldm^{-3}$ c. 0.25 mol dm^{-3} d. 1.0 mol dm^{-}

5. The molarity of a given solution is the same as

   a. mole of dilute in a given volume of solution

   b. mass of solute in a given volume of solution

   c. mass of solute in 1 dm^3 of solution

   d. mole of solute in 1 dm^3 of solution

6. What mass of $CaCO_3$ must be decomposed to give 22 g of CO_2?

   [$CaCO_{3(g)} \longrightarrow CaO_{(g)} + CO_{2(g)}$; C = 12, O =16, Ca = 40]

   a. 100g   b. 50g   c. 200g   d. 500g

7. The number of atoms in one mole of a substance is equal to the

   a. Atomic number b. Avogadro's number c. Mass number d. Oxidation number

8. A solution of K_2CO_3 contains 27.6g of the salt per 200 cm^{-3} of solution. Calculate its concentration in mol $dm^{-3.}$ [K_2CO_3 = 138]

   a. 0.20 $moldm^{-3}$ b. 0.25 $moldm^{-3}$ c. 0.50 $moldm^{-3}$ d. 1.00 $moldm^{-3}$

9. How many atoms are there in 0.3 mol of an element? [L= 6.02×10^{23}]

   a. 2.0×10^{24} b. 1.8×10^{24} c. 1.8×10^{23} d. 3.0×10^{22}

10. How many moles of oxygen would contain 1.204×10^{24} molecules?

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

11. Under the same conditions of temperature and pressure, 28 cm^3 of nitrogen gas will have the same number of molecules as

    a. 16cm^3 of oxygen b. 28 cm^3 of oxygen c. 28 cm^3 of oxygen d. 28 cm^3 of oxygen

12. What mass of Na_2CO_3 would be required to prepare 250 cm^{-3} of 0.15 $moldm^{-3}$ solution? [Na_2CO_3 = 106]

    a. 3.98g b. 13.25g c. 15.90g d. 63.60g

13. Consider the following reaction equation: $4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$

    [Al=27, O=16]

    How many moles of Al_2O_3 would be formed when 27.0g of Al reacts completely with O_2.

    a. 4.0 b. 2.0 c. 1.0 d. 4

14. What is the amount of potassium hydroxide in 250 cm^{-3} of 0.05 $moldm^{-3}$ of its solution?

a. 0.0125 moles b. 0.1250 moles c. 1.2500 moles d. 12.5000 moles

15.What volume of 0.20 mol dm^{-3} solution of NaOH would yield 5 g of solid NaOH On evaporation? [NaOH = 40 g mol^{-1}]

Section B (Essay)

Attempt all questions

1. A container holds 3.7g of diethhylether $(C_2H_5)_2O$ vapour. Calculate

   i). the number of moles of $(C_2H_5)_2O$ present.

   ii). the volume of the vapour at s.t.p.

   iii). the number of molecules of $(C_2H_5)_2O$ present.

2. Calculate the concentration in (a). $moldm^{-3}$ (b) g/dm^3

   of a 0.5g NaCl dissolved in 150.0 cm^3. of water.

3. Powdered aluminium reacts with iron (III) oxide to produce aluminium oxide and molten iron. What mass of aluminium oxide is produced when 2.3g of Aluminium reacts with iron (III) oxide?

   The equation for the reaction is: $2Al + Fe_2O_3 \longrightarrow 2Fe + Al_2O_3$

4. In a class of 25 students, if each student is to be supplied with 120 cm^3 of 0.2 M solution of sodium trioxocarbonate (IV), Na_2CO_3, calculate:

   (i). the total volume of solution needed by the students.

   (ii). the total mass of Na_2CO_3 that you would have to weigh to prepare this solution.

5. What volume of 0.30 M H_2SO_4 would contain 1.35 g H_2SO_4?

APPENDIX C

QUESTIONNAIRE FOR STUDENTS

This questionnaire is designed for academic purpose. The researcher needs information that would be used to improve academic performance of students and therefore would be very grateful if u can give honest responses to the questions below.

INSTRUCTION: Please tick the appropriate response to each item.

KEYS: SA= Strongly Agree, A=Agree, D=Disagree, SDA=Strongly Disagree, NS=Not Sure **PERSONAL DATA**

1. Sex Male [ ] Female [ ]
2. Age……………………

Item /Options	SA	A	SDA	D	NS
1. Mole concept is very difficult to understand.					
2. Mole concept is very interesting.					
3. I dislike studying the mole concept.					
4. Mole concept is very confusing.					
5. I enjoy solving problems on the mole concept.					
6. Mole concept formulas, symbols and units are easy to understand.					
7. I like the teachers teaching style.					
8. I do not understand what the teacher teaches.					
9. Learning the mole concept is not necessary for my future.					
10. I sometimes dodge classes because the lesson is boring.					