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# INCORPORATING STIMULATING QUICK-WRITE PROMPTS WITHIN A SECONDARY SCIENCE CLASSROOM: A CASE STUDY IN LESOTHO

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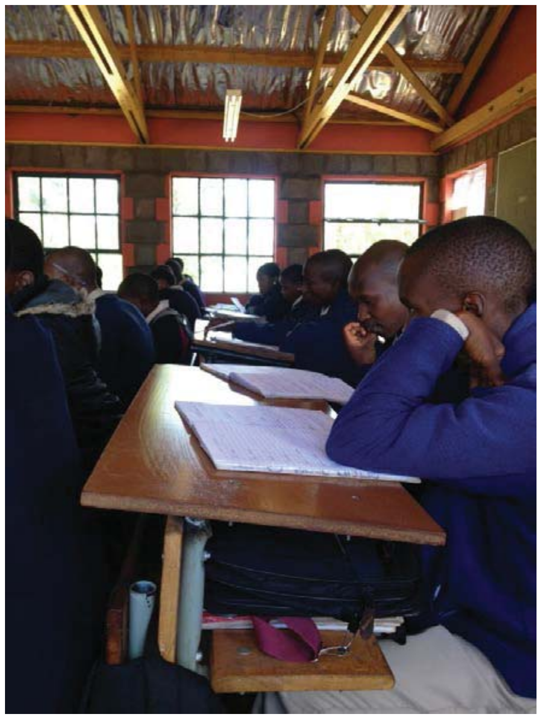

"Our greatest weakness lies in giving up. The most certain way to succeed is always to try one more time." – Thomas Edison

**Abstract**

Incorporating Stimulating Quick-Write Prompts Within A Secondary Science Classroom: A Case Study in Lesotho

By

Eduardo J. Cabret

The use of intriguing open-ended quick-write prompts within the Basotho science classroom could potentially provide a way for secondary teachers in Lesotho to have a time-efficient alternative to stimulate student thinking and increase critical thinking or application of scientific principles. Writing can be used as a powerful means to improve the achievement of students across many subject areas, including the sciences (Moore, 1993; Rivard, 1994; Rillero, Zambo, Cleland, and Ryan, 1996; Greenstein, 2013). This study focuses on the use of a non-traditional nor extensively studied writing method that could potentially support learning in science.

A quasi-experimental research design, with a control and experimental group, was applied. The study was conducted at two schools, with one experimental classroom in one school and a second control group classroom in the second school for a period of 4 weeks. 51 Form B (US Grade 9 equivalent) students participated as the experimental group and 43 Form B students as the control group. In an effort to assess learning achievement, a 1 hour (35 mark) pre-test evaluation was made by and given to students by Basotho teachers at the beginning of this study to have an idea of student's previous knowledge. Topics covered were Static Electricity, Current Electricity, Electromagnetic Waves, and Chemistry of Water. After the experimental trial period, an almost completely identical post-test evaluation was given to students in the same fashion to observe and compare gains in achievement.

Test data was analyzed using an inferential statistics procedure that compared

means and gains in knowledge made by the experimental and control groups. Difference between the gains of mean pre-test and post-test scores were statistically significant within each group, but were not statistically significant when the control and experimental groups were compared. Therefore, there was no clear practical effect.

Qualitative data from teachers' journals and students' written feedback provides insight on the assessments, incorporation of the teaching method, and the development of participating students. Both mid and post-study student feedback shows that students had an overall positive and beneficial experience participating in this activity. Assessments and teacher journals showed areas of strength and weaknesses in student learning and on differences in teaching styles. They also helped support some feedback claims made by students.

Areas of further research and improvement of the incorporation of this teaching method in the Basotho secondary science classroom are explored.

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# Chapter 1: Problem Statement

It has become widely known and recognized by many scholars in the education field that writing can be used as a powerful means to improve the achievement of students across many subject areas, including the sciences (Greenstein, 2013; Rillero, Zambo, Cleland, and Ryan, 1996; Rivard, 1994; Moore, 1993). There is evidence that writing activities can support the development of critical thinking skills and shift both teachers and students from traditional rote and memorization toward a more interactive classroom environment and answering more divergent types of questions (Cleland, Rillero, and Zambo, 2003; Dobyns and Lewis, 2001; Torrance and Myers, 1970). Nevertheless, incorporating additional writing techniques in a class typically implies that teachers would have to place extra effort on grading, obtaining, and providing feedback to students for their writing. However, using simple and intriguing open-ended prompted questions for a brief amount of time at the beginning of a class allows for student participation and teacher feedback to be much less tedious and time consuming (Cleland, Rillero, and Zambo, 2003). This study focuses on demonstrating that the use of writing supports learning in science instruction.

## *Background of Study*

This study was conducted while I served as an Applied Science Education Peace Corps Masters International (PCMI) M.Sc. graduate student from Michigan Technological University (MTU). My main responsibilities upon being placed in a country of service were to serve two education sectors from opposing regions of the African continent as a Peace Corps Volunteer (PCV) in a span of 30 months. My service began in the Republic of The Gambia located in West Africa where I was assigned to be a Science Teacher Trainer and Evaluator for The Gambia College, a vocational post-secondary government institution. After 22 months of service in West Africa, I was transferred for the remainder of my 5 months of service and a month extension to the Kingdom of Lesotho in Southern Africa. While in Lesotho, my primary duties were to serve as a secondary Physical Geography and Life Skills teacher within Renekeng Secondary (High) School, a small rural government institution with roughly 175 students in three grade-levels taught by 6 fully certified Basotho teachers. The school is located between the villages of Ha Motsie and Ha Ramosalla; roughly 80 km northeast of the nation's capital in the township of Peka (Leribe District). Primary education in Lesotho is free and obligatory until grade 7 for all children in the nation up to 13 years of age. Nevertheless, secondary education is not obligatory and comes at a cost. Furthermore, there is a higher female to male student ratio at this level, especially within wealthier communities (UNICEF).

Lesotho also has two main post-secondary institutions; the public National University of Lesotho in Roma, 34 kilometers southeast of the nation's capital of Maseru where a campus of the private Limkokwing University of Creative Technology is located. At the national university, students who attend can obtain degrees in Agriculture, Education, Health Sciences, Humanities, Law, Social Sciences, Science, and Technology. Private institutions offer more technological, design-based, and communications oriented degrees. An individual citizen of Lesotho is referred to as a Masotho and its people as a whole are referred to as Basotho or Sotho people who are of a Bantu-language or Sesotho-speaking Southern African ethnic group (CIA – The World Factbook). The country is rich in culture, but has a poor economy mainly based on agriculture, livestock, textile manufacturing, and the mining of diamonds (ibid.). The majority of Basotho households subsist on farming (ibid.).

The purpose of this research was to determine whether utilizing intriguing and time-efficient open-ended prompted questions at the very beginning of each class positively influences learning science and boosts self-confidence amongst students within the Form B (USA Grade 9 equivalent) science classroom.  The plan was to provide a local teacher with a different means of assessing and improving student performance at little change to the current academic environment and at little cost to imposing a bigger workload on Basotho teachers.  Writing would be used to engage students' prior knowledge and facilitate explorations of alternative ideas, thus stimulating or strengthening critical thinking skills (Cleland, Rillero, and Zambo, 2003).

### *Hypothesis*

The study hypothesized that fully embracing the use of intriguing open-ended quick-write prompts and statements within the science classroom could provide a time-efficient means for secondary teachers in Lesotho to stimulate student thinking and potentially increase critical thinking or application of scientific principles.  The use of these types of questions should, with sufficient time of exposure, hone particular thinking skills or capabilities such as increasing retention which could also in turn possibly deepen student understanding of subject content while also potentially improving the current ability of students to make connections between the content being studied in class and their daily lives (Maxwell, 1996).

### *Research Question*

Could the use of intriguing, open-ended, quick-write prompts provide a way for secondary teachers in Lesotho to have a time-efficient means to stimulate student thinking that would increase self-confidence and academic performance in their science classroom?

## Chapter 2: Literature Review

Cleland, Rillero, and Zambo (2003) carried out a study where teachers created prompted or peculiarly pre-designed questions that were focused on concepts from material that had already been taught; their prompted questions relate to a topic previously covered by a teacher. They traced a variety of ways in which a quick-write technique can be implemented within the science and mathematics classrooms of an urban North American middle school and demonstrated which prompted questions brought forth high quality responses from participants in order to provide a recipe for constructing highly effective questions. They identified four different ways in which students would provide higher-end responses as follows: engaging an idea into practice, alluding to creativity, providing personal views, and offering a rationalization of a given statement. Furthermore, these researchers were able to identify which qualities make a highly functional prompted question and they came up with the following: "being open-ended, having real-world relevance, and allowing students the opportunity to state and support their own ideas (Abstract, p.1)."

Woolnough (1999) performed an action research study involving the use of a questionnaire where he found that ninth grade students from the United States when using their own informal means of writing and providing concise ideas made their learning fun and conducive. Hanrahan (1999) performed a study involving answering prompts in journals. Students had to do so by writing typically no more than 2 sentences. This was found to be positively welcomed and preferred by most of his students over previous classroom writing practices, but a minority did find themselves struggling to think about how to respond.

Mason, Benedek-Wood, and Valasa (2009) found that using focused quick-write prompt questions increases achievement of low-achieving students within their content-area writing in the United States classroom. Randy Moore (1993) proved that not providing guidance when students write about science does not improve student's achievement in learning science. Both studies could translate into offering a means where the use of this teaching method can increase the achievement of international students who are also low achieving. Furthermore, this could probably even be more effective with poor achieving Basotho students rather than with students from the United States mainly due to differences in factors associated with being raised within diverse social settings generally influenced by the level of development.

Not having the necessary writing skills limits student's capacity to clearly formulate and express ideas that demonstrate learning (Gunning, 2002). Being able to properly and competently write to clearly state ideas and be proficient with subject matter is of high importance, but certain skills must be achieved first in order for students to do so. Greenstein (2013) used an approach not meant to necessarily teach students how to write or improve in their writing, but to write for the encouragement of thinking and learning in science. Her findings demonstrated that having students regularly write brief to extensive compositions, without having to stress over neither grammar nor continuous assessment of student's writing, was helpful for students in the science classroom. Furthermore, she found that not having sufficient background knowledge in science is not a precursor for critical or intelligent thinking to emerge and writing science using her technique makes learning a more active classroom experience. Nevertheless, she also realized that student writing needs to sometimes be evaluated and graded at least at a random fashion in order for students to realize that writing does help them do better and that their efforts are not in vain.

Using intriguing quick-write questions motivate students to want to learn, as questions are fun and don't elicit a particular answer (Dobyns and Lewis, 2001).

Thus, such questions challenge their creative thinking while improving their critical thinking and can be used across all subject areas with all types of learners (Torrance and Myers, 1970). Quick-write prompts in the science classroom focus the student's mind on a particular subject at hand without the need to stress about assessing their proper use of spelling and grammar (Greenstein, 2013; Cleland, Rillero, and Zambo, 2003). Nevertheless, it can be difficult at times for students to relate their environment and life experiences to the more complex scientific concepts of a science curriculum because it tends to be much easier for students to make connections and relate to non-scientific subjects in school given that these other subjects are much less analytical and technical (Greenstein, 2013).

Incorporating guided, subject-focused, open-ended, prompted questions in the science classroom that allude to the real world and comfortably allow students to bring forth their own ideas that stimulate critical thinking and increase student achievement, have been used by many science teachers across many classrooms of the United States. Current findings in the literature suggest that such efforts could just as successfully be applied in the developing world and across subject-areas. Informal means of writing and stating one's own ideas without necessarily having been previously exposed to subject material in the science classroom makes learning fun for students and such prompted questions have been more favorably welcomed by students than traditional writing assessments.

The stress factor that arises from worrying about proper writing skills is removed in the science classroom. Also, incorporating this technique consumes only 5 to 10 minutes of class time and does not add to the current workload of teachers. Problems of poor achievement in math and the sciences among students that learn by using their second language, versus their native tongue, has been directly correlated with deficiencies in English writing skills, thus not easily allowing for needed writing skills to be properly acquired (Mayaba, Otterup, and Webb, 2013). Nevertheless, African contexts that explore and research the implementations of the technique used in this study are lacking.

Furthermore, "[t]he links between writing to learn and critical thinking have not received sufficient attention. Carefully designed studies, both qualitative and quantitative, are still required to provide data from a variety of perspectives" (Rivard, 1994, p. 969). Utilizing writing-to-learn techniques such as prompted questions for quick writing within the beginning of any science classroom may be a way of stimulating in students a unique way of thinking that could take them away from the traditional teaching and learning practices of wrote and memorization.

# Chapter 3: Methodology

A quasi-experimental research design, with a control and an experimental group, was applied. The study was conducted at two schools, with one experimental classroom in one school and a second control group classroom in the second school. Renekeng Secondary School, where I was based, was the experimental school. The control group was at Ha Ralikariki High School.

Human Subject Research approval was obtained from Michigan Technological University's Internal Review Board and Office of Compliance, Integrity, and Safety in order to begin collection of research data and ethically carry out this research. This study did not entail the use of any compromising personal identifying information nor did it negatively hinder participating students and teachers in any way. The Leribe District Education Ministry Officer and Renekeng High School's Principal received a copy each of the research plan and gave verbal consent to both the participating teachers and myself to carry out this study. This study is also considered as a professional development opportunity, given that the investigator worked alongside and facilitated the school's resident science teacher.

### *Experimental School*

Renekeng Secondary School is a small public institution between the villages of Ha Motsie and Ha Ramosalla within the northern district of Leribe, roughly 80 km northeast of Maseru, Lesotho's capital. There were roughly 175 students enrolled in the school and class sizes varied from 40 students in the upper levels to over 80 students in the lower levels at the time of this study. I was the only native English-speaking teacher and worked at the school with 6 Basotho teachers, principal included. The school used three classrooms to house the three grade levels it taught; Form A, B, and C (USA equivalent of Grades 8, 9, and 10 respectively).

### *Control School*

Ha Ralikariki High School is a larger secondary public institution located in the village of Ha Ralikariki within the same northern district of Leribe, but 10 km southeast of Renekeng Secondary School. There were roughly 236 students enrolled in the school and class sizes varied from 40 students in the upper levels to about 60 students in the lower levels at the time of this study. There was a native English-speaking Peace Corps Volunteer teacher who worked alongside 9 other teachers (2 of which were Basotho volunteer teachers). The school contained two additional grades, Form D and E (USA equivalent of Grades 11 and 12 respectively), and used 6 classrooms to house all 5 grade levels (Form A to E; Form As were the only group distributed within two classrooms).

Both schools were selected based on sampling availability given that both of these were the only public secondary schools in the region to have the most similar settings in terms of rural location, lack of resources, and containing only one Form B group about the same in class size to minimize bias and unwanted variables as much as possible. Participating Form B groups from both schools were relatively about the same size, although the Form B group in Ha Ralikariki had a larger female to male ratio than Renekeng Secondary's Form B class.

The study was designed to minimally impact each participating school's current academic environment and science curriculum.

### *Teacher Selection Criteria*

As a requirement I set for this research, participating teachers had to be qualified (no Teacher Trainees / Student Teachers). They also had to have at least 2 to 3 years of the items below:

- Certified teaching experience.

- Form B Ministry of Education science curriculum teaching experience.
- Teaching at their current schools.
- Successfully demonstrating at least 50% or more of their Form B science students passing each year or a noticeable improvement in Form B-level science student achievement from year to year.

***Control group (B): Participating Teacher and Students***

The Form B science class of 47 students from Ha Ralikariki High School did not receive any treatment, thus serving as the control group. Their science teacher was a 28-year-old male who lived in the adjacent village of Lihlabeng. He was certified and qualified to teach by the Lesotho College of Education. At the time of this study, he had 2 years of overall teaching experience as a faculty member within the same school that had been teaching the Lesotho Ministry of Education's Form B science curriculum. During those 2 years, the teacher had a ≥ 45% passing rate in Form B science. He also developed complete and very detailed daily lesson plans with remarks on the outcomes of each lesson and also kept an assigned daily teacher journal.

***Experimental group (A): Participating Teacher and Students***

Renekeng High School's Form B (USA Grade 9 equivalent) science class of 54 students and their teacher participated. Renekeng High School Form B students answered quick-write prompts provided by their science teacher at the beginning of each class for 5 to 10 minutes. Thus, serving as the experimental variable. Their Form B science teacher was a 49 year-old male who lived in the adjacent village of Ha Rantuba. He was certified and qualified to teach by the Lesotho College of Education as well. At the time of this study, he had 26 years of overall teaching experience; 8 of those years were spent teaching the Ministry of Education's Form B science curriculum and 7 of those years as a faculty member within Renekeng Secondary School. For the last 5 years, this teacher reported to have had a > 50% passing rate in Form B science. Nevertheless, this teacher did not develop nor provide detailed daily lesson plans. He rather provided daily summaries of each lesson with his reflections in his assigned teacher journal.

### *Grade-level Selection Criteria*

Given that Form A students (US Grade 8 equivalent) are adjusting to their first year within the High School and secondary school system, they were considered an unstable population for this study because they are adapting to this new environment. Similarly, Form C students (US Grade 10 equivalent) are focused on and busy working towards their Junior Certificate standardized exams and, though they would have been good candidates for this study, their focus as well as that of their school's administration was on providing students with ample time throughout the academic year to prepare for the exams. Therefore, the Form B (US Grade 9 equivalent) students were selected to participate in this study given their level of stability or adaptation as they had established themselves nicely within the Secondary (High) School environment and were not focusing on standardized exams as of yet.

### *Academic Term Selection Criteria*

In order to give this study even more stability that would further minimize unwanted bias or errors, it would have been ideal that the 4-week experimental trial period took place within the middle of the academic year during either the 2$^{nd}$ or 3$^{rd}$ Quarters. But, given circumstances out of my control such as having to transfer from Peace Corps The Gambia to Peace Corps Lesotho towards the end of an academic year in a different region of the continent, this research took place towards the beginning of the academic year's 4th quarter on October 14, 2013 after all logistics, permissions, and materials were sorted.

### *Instruments*

Instruments measured student knowledge of concept taught. To assess learning, a 1 hour / 35 marks pre-test (*see Appendix A*) evaluation was made by teachers, using questions from already existing exams, and given to students by their respective teachers at the beginning of the experiment in order to obtain an idea of students' previous knowledge on the topics that were to be covered during the duration of the experiment. These topics were Static Electricity, Current Electricity, Electromagnetic Waves, and Chemistry of Water. After the experimental trial period, an almost completely identical post-test evaluation (*see Appendix B*) was given to students by their teachers in order to see the magnitude of each group's gains and compare both of these in hopes that the experimental group would have a higher or significant difference in gains. Furthermore, the incorporation of intriguing prompted quick-write questions and statements in the science classroom (*see Appendix C*) should help Renekeng's science teacher improve his student's overall achievement in learning science through the positive effects they might be benefiting from by the frequent stimulation of their thinking skills and capacities while attempting to answer such prompts on a daily basis during schooling days. The open-ended and intriguing nature of these prompts also facilitates the participation of all students with ease, most likely empowering students and boosting their self-confidence in the subject. A few of the post-test wording of question instructions were slightly modified in an effort to see if students would properly answer the questions by understanding more clearly what was asked. Nevertheless, the actual questions and exercises to be answered remained the same as the pre-test.

I was not present in the classroom of the control group, but I was somewhat visible in the experimental group classroom, where I volunteered during the period of the experiment. The intent was to minimize bias, fear (anxieties), or confusion amongst participating students and to avoid, as much as possible, disrupting the current school settings. The assessment tools were used in both schools and were created by Teacher B using already existing exams. Teacher A and I discussed, made small changes, and agreed to proceed. Using a word processing software, I digitalized figures and typed the documents. Subsequently, I also printed and photocopied these for each student.

No personal information, other than sex, age, and village of current residency of students, as well as the years of teaching experience of teachers, were obtained to provide some background information of each individual and for potential further research purposes. Students who participated as the experimental group were given by their teacher the opportunity to also provide anonymous feedback on the use of this new method on two different occasions using the same open-ended prompted statement during the middle and after the completion of this study; "*Write anything you would like to express your opinion and/or provide any recommendations on your participation and the use of this activity as part of class*" (*see Appendix C*). Although these may provide us with an idea of the level of student receptiveness to this teaching method, students will provide feedback in the form of a personal and most-likely biased opinion. Therefore, such qualitative data is not meant to serve as a direct, primary, or significant means of evidence to support the hypothesis, but it was used to support some of the opinions or claims the students provided. This, in turn, slightly does support the hypothesis. The students in the experimental group recorded their quick writes and feedback in notebooks that were collected at the end of class in order to keep track of participation and progress. Each student was assigned an identifiable letter and number as a means to keep track of assessments and notebooks.

Each Group's science teacher kept a teaching journal where they were asked to openly reflect on their students and teaching, particularly on lesson development and student progress, during the duration of the study. This was done in order to shed light on what took place in both classrooms and help support feedback opinions or claims made by students in Group A. Meetings in preparation for this experiment were held with each teacher individually at their particular schools before the research plan was carried out during the second half of the $3^{rd}$ quarter.

***Materials***

The materials required for this research study included: 58 A5-sized (72-page) notebooks to record and keep track of the quick-write prompts and/or reflections (including 1 for each teacher), 58 writing utensils, and printing in order to photocopy the pre and post assessments for all students. For the purposes of this project and as an incentive for school, teacher, and student participation, all expenses were covered using funds obtained from my monthly volunteer stipend. Students were also given the incentive of receiving one piece of candy for every quick-write prompt they answered by coming to class and adequately participating each day.

**Table 1: Assessment Administration Schedule**

| | **Pretest Administration Date** | **Posttest Administration Date** |
|---|---|---|
| **Experimental Group (A)** | October 14, 2013<br>(n= 51)* | November 7, 2013<br>(n= 54)* |
| **Control Group (B)** | October 14, 2013<br>(n= 45)* | November 6, 2013<br>(n= 47)* |

*****_The 'n' values are the numbers of students who took the test. 30 of the participants (23 in Group A and 7 in Group B) in this study were students who were repeating the grade level._

***Data Analysis Procedures***

A mixed methods approach has been used to analyze the data. The test data were analyzed using an inferential statistics procedure that compared the gains in knowledge made by the experimental and control groups. The statistical procedure t-test was employed for that purpose. In addition to that, the data were analyzed qualitatively by identifying major themes emerging from students' written feedback and teacher reflective journals that would support claims made by students in Group A with regard to the success of the incorporation of this activity in the classroom.

# Chapter 4: Results and Discussions

## *Quantitative Results*

The initial total population of Group A (experimental group) was of 55 students and that of Group B (control group) was of 49 students. Students who presented themselves to class and participated in both pre and post assessments at the very beginning and end of the 4-week trial period were considered in the data analysis; Four students in Group A and 6 students from Group B, for a total of 10 students, did not follow the requisite and therefore their data were not included for analysis. The number of students who had participated in both assessments subsequently decreased to 51 in Group A and 43 in Group B.

A total of 30 students were repeating the grade and thus the same science course. Data values of 29 of these students who underwent both assessments were initially considered given the belief that this population would perform differently than those of students in both groups who were exposed to the science topics for the first time. However, this sample population (n = 29) was included together with the non-repeater sample population (n = 65) in the data analysis because statistical tests demonstrated that both of these groups were equivalent. By considering both repeaters and non-repeaters as one sample population of students, the degree of error in sampling was expected to be small given that the number of students that did not qualify to participate in this study was lesser (n = 10) in comparison to the total amount of students that qualified to participate (n = 94). Therefore, 90% of the combined Group A and B student populations were able to participate and their data fully included in this study.

*Pre-test Analysis*

To further assess the two classrooms for equivalency, a statistical analysis of pre-test data was conducted (Table 2).

**Table 2: Statistical Analysis Results of Pre-test Data**

| | GRP | N | Mean | Std. Deviation |
|---|---|---|---|---|
| Pre-test | Experimental | 51 | 6.75 | 4.28 |
| | Control | 43 | 4.53 | 2.97 |

On the t-test analysis of pre-test scores, the difference between the experimental and control groups was found to be statistically significant ($p = 0.002$). The experimental group was stronger or overall performed better than the control group prior to the intervention.

**Table 3: Averages of student scores based on a 35-mark Pre- and Post-test**

| Experimental | | | Control | | |
|---|---|---|---|---|---|
| Pre-test (Mean scores) N = 51 | Post-test (Mean scores) N = 51 | Mean Gain value | Pre-test (Mean scores) N = 43 | Post-test (Mean scores) N = 43 | Mean Gain value |
| 6.75 /35 (19.3%) | 13.13 /35 (37.5%) | 6.37 | 4.53 /35 (12.9%) | 11.99 /35 (34.3%) | 7.45 |

The summary of the pre- and post-test analysis are indicated in Table 3. The average gain for the control group was 7.45, and that of the experimental group was 6.37. A t-test of gains was conducted, comparing the control and experimental groups. The results showed no significant differences.

The experimental group showed significant increases from pre to post test, but the pre- to post-test gain for the control group was not significantly different from that of the experimental group. There are some possible reasons for the absence of significant gains. First, an effort was made to find equivalent classrooms with equivalent teachers. However, there were differences in the teachers and their instructional methods that could not be controlled. In addition to that, the pre-test data analysis appeared to indicate that the student characteristics for the two classrooms were not precisely matched. Another factor is the short duration of the study. In summary, the quantitative data were inconclusive.

### ***Qualitative Findings***

The qualitative findings are of two types. The first set of data is based on the analysis of students' responses to quick-write prompt questions. The second set of findings is from the analysis of students' responses to knowledge-type questions on the pre- and post-tests. The responses to the knowledge type questions are discussed first,

### ***Experimental Group A (Pre and Post-Assessment)***

Mean score doubled from the pre-test to the post-test and, overall, students improved in almost every question as expected (*see Table 3 and Appendices J and L*). Nine % of students had trouble differentiating between "contracting" or "to contract" and the correct "attraction" of unlike charges in both assessments. In the post-assessment, 5% of students were trying to make sense of how a gold leaf electroscope works by trying to use an example discussed in class on lightning which seemed to cause confusion. Also, about 9% of students were confusing the function of an electroscope with a microscope by indicating that the gold leaf electroscope "*makes far things to be near*" and "*allows us to see objects that are very small and cannot be seen with the naked eye*" which is not the function of a gold leaf electroscope as it tests for the presence and type of charges present within a charged object.

Students confused a voltmeter and voltage with an ammeter when having to identify it on a given electrical circuit diagram. In this test question, the percentage of students doubled from 5.5% in the pre-test to 10.9% in the post-test. When adding an additional third light bulb to a closed electrical circuit, students increased from 7% to 18% in their belief as a valid answer that the addition of this bulb would cause for the brightness of the other bulbs to be stronger. This is not the case as all of the light bulbs would actually do the opposite and decrease their brightness. Quite similarly, with an increase from 7% to 19%, students believed that adding a cell in series would not light or do so very weakly.

Concepts such as 'disadvantages', 'difference', and the ability to provide answers correctly explaining the 'how', 'why' or 'what' of something were a challenge for students. Students became very good at scientifically understanding the difference between light waves and sound waves with an increment from a 9% to a 72.7% of students demonstrating an understanding between both concepts in the assessments (*see Appendices J and L*). However, the class did not seem to recover from identifying instruments or an apparatus that can function with the use of light such as a light microscope or binoculars. Only 12% of the class was successful at correctly answering this question in the post-assessment after no one had gotten the question correctly in the pre-assessment. Nevertheless, such items are not easily accessible to teachers and students neither at schools nor at home. The most popular wrong answer was the mirror, but technically it is not an apparatus as expressed by both teachers. Furthermore, students that identified sound waves as electromagnetic waves increased from 10.9% to 14.5%. The last section or Question IV on Chemistry of Water seemed to be the one with the least improvement.

***Control Group B (Pre and Post-Assessment)***

The mean score almost tripled from the pre-test to the post-test and, overall, students improved in almost every question (*see Table 3 and Appendices K and M*). Students initially did quite well and even improved in static electricity. As with Group A, this group showed in their pre-test that they (16%) also initially confused how a gold leaf electroscope works and functions with "*bring[ing] far object[s] closer and make it [them] bigger so that you can see*" and to "*look for the small things*", but this mistake was surprisingly not a major issue in their post-test.

With regard to current electricity, the class seemed to initially confuse a "circuit" with a "switch" in the pre-test, but the misconception must have been addressed in class as it did not resurface in the post-test. When adding an additional third light bulb to a closed electrical circuit, 12.5% of students in the post-test reported that they believed that the addition would cause for the brightness of the other bulbs to "*light very brightly*". This is not the case as all of the light bulbs actually do the opposite and decrease their brightness, but the same amount of students had also reported that the cell battery "*is finished fast*" and a correlation might exist.

About the same student post-test percentage relationship was observed when students believed that adding a cell in series would not light or, if so, would do so very weakly which a population of students from Group A also believed. Group B did not demonstrate comprehension in differentiating between a cell battery and the ammeter. Concepts such as 'disadvantages', 'difference', and the ability to provide answers correctly explaining the 'how', 'why or 'what' of something were much more of a challenge for these students. The disadvantage of connecting streetlight in series was erroneously described by 30% of the class as "*the batteries [cell] are going to be* *flat [become depleted of energy] so very fast*" in the post-test. The class did not seem to improve from identifying instruments or an apparatus that can function with the use of light such as a light microscope or binoculars. Only one student was successful at correctly answering this question in both the pre-test and the post-assessment by providing the microscope as his answer.

Nevertheless, such items are not easily accessible to teachers and students neither at schools nor at home as previously stated. The most popular wrong answer was initially the torchlight (7%) and then substantially the mirror (25%). Again, although a mirror might sound reasonable to many students, it is technically not an apparatus as expressed by both teachers. Furthermore, students that identified sound waves as electromagnetic waves in this group decreased in half from 24% to 12%. The last section or Question IV on Chemistry of Water seemed to be the one with the most increase in improvement for this group, with the exception of differentiating between hard water and soft water where number of correct answers and those not attempted remained just about the same with only a slight increase in correct answers from 2% to 3% which was also the case for Group A.

***Major Differences of Final Outcomes***

Concepts such as 'disadvantages', 'difference', and the ability to provide answers correctly explaining the 'how', 'why or 'what' of something were much more of a challenge for Group B.

When attempting the static electricity question, *Why is the observed behavior of the balls occurring?*, 16% of students in the experimental group almost attained full credit by providing four types of partial answers in the post-test; *unlike charges between 'y' and 'z', like charges repel, unlike charges attract, and 'they are charged'*. In comparison, 6% of the control group achieved the same although they had done so by providing only two types of partial answers (*unlike charges attract* & *they are charged*) in the final assessment. With regard to the operation and function of a gold leaf electroscope, a greater amount of students (56%) in Group A was able to provide a partial answer when compared to the lesser 34% of students observed doing so in Group B. Hence, as not even a single student was able to achieve full credit in these two questions, the post-test demonstrates that students were, overall, not able to make the necessary connections and achieve the subsequent deeper understanding.

The 'ammeter' was labeled correctly on the electrical circuit diagram by a great majority (80%) of the control group versus the almost half proportion (44%) of students in the experimental group. Therefore, a large number of students were able to clarify confusions between the component and a cell battery.

Not a single student in Group B was able to provide any form of a valid answer to identify the disadvantage of connecting streetlights in series, but a quarter of Group A successfully did so. However, slightly higher than a quarter of students in the experimental group (29%) was able to suggest a way of avoiding the disadvantage. Only 6% of the control group achieved in doing so.

The difference between light waves and sound waves was fully understood by a high majority of students in Group A (80%). Only 28% of Group B did so in the same fashion. Feebly and similarly to the questions on connecting streetlights in series, a quarter of the experimental group correctly identified the angle of reflection when a light ray is incident to a plane mirror, while a much improved 62% of the control group dominated this question.

The mathematical practicality of speed was dominated better by 36% of students in Group A versus only one student in Group B who obtained full marks. Nevertheless, 50% of students in the control group were able to provide a partial answer thus showing somewhat of a substantial improvement in their mathematical abilities from their pre-test performance. Furthermore, about half of Group A (40%) knew the speed electromagnetic waves travel at and only a minority of students in Group B (10%) did so.

Identifying substances removed by a screening tank and understanding the difference between hard and soft water was attained better by the experimental group. Results showed that 37% of students provided fully correct answers when compared to the respective 22% and 12% the control group achieved in each of these two areas or questions.

Mean scores from pre-test to post-test of Group A had doubled and Group B's mean scores had almost tripled. Nonetheless, end results demonstrate that the experimental group had performed better overall on a greater set of questions than the control group based on the major identified differences previously discussed. The discussion now turns to students' responses to quick-write prompt questions as used with the experimental group.

***Students' Response to Quick-Write Prompts***

It seemed somewhat of a challenge for Group A to grasp concepts and make appropriate connections. At the very beginning of this study, Teacher A expressed that "*It was difficult for students to actually differentiate between static and current electricity. However, after giving examples of the instances where static electricity occurs, the concept was better understood by the students, but how it occurs was still a problem.*" This statement indicates that students were able to learn with the aid of good examples, but experienced difficulties with really making connections. Towards the end of the study, Teacher A again reported a situation while discussing the topic *Types of waves and their properties*. He said: "*Students knew two types of waves* *being longitudinal and transverse waves though they did not know their differences*". Following subsequent lessons the teacher reported the following: "*With the knowledge of static electricity, students were able to realize that charged objects can repel or attract.*" "*Students experimented with gold leaf electroscopes. They were later asked to explain their observations. It was not easy for them to realize that the leaf deflected due to the movement of electrons to or from the charged object. However, they realized that the leaf deflected because there was a charge.*" "*It was not easy for students to find out how ions can be removed in hard water*". The teacher attempted to address these by providing further lecturing. Nevertheless, making real connections seemed to be an issue for a number of students on the post-assessment, even after modifying the post-assessment in an effort to ease their understanding and even after having been pre-exposed to the concepts in the pre-test.

Secondary schools in the country are greatly limited with respect to teaching aids and materials for demonstrations and experiments. This affects the quality of teaching. "*The echo is well understood due to reflections of the sound*".

***Post-study Student Feedback***

During both feedback days, students were anonymously asked by their teacher to "*Write anything you would like to express your opinion and/or provide any recommendations on your participation and the use of this activity as part of class.*" (*see Appendix C*). Students mostly gave positive feedback. They felt like they had gathered new knowledge by making their own connections. Students felt challenged and thus encouraged to study and work hard. Some students reported after the completion of this study that the activity and science topics covered were: highly important and beneficial (81%), expanding their vocabulary (20%), a means of encouragement to read and write (17%), and as having the ability to apply newly acquired knowledge with more ease (35%).

Some recommendations were also made by 13% of students to continue with the activity after the end of the study. One student pointed out that doing so should simplify a teacher's workload. The single student who provided negative feedback mentioned that the activity was a waste of class time and thus not important. A more in-depth look at the nature of these weaknesses or patterns could be of great interest in the future. One recommendation was made by a student for the teacher to obtain more materials for conducting more in-class experiments and demonstrations as an alternative to this writing exercise.

Students responded to the following prompt. "*Suppose you were given a piece of copper wire, a cell battery, and a light bulb. Show with the use of a drawing how you would connect these materials together in order to make the bulb light.*" Students drew diagrams of electrical circuits in response. Their drawings were mostly incorrect (88%). They incorrectly represented symbols as they tried to mimic what they had seen in their class textbook when attempting to read ahead. It was notable that the students were also reading ahead when they did not fully understand. The use of prompt questions at the beginning of lessons was the catalysis that encouraged them to read. In this sense, the use of prompt questions had a positive influence on the students' learning behaviors. Teacher A confirmed that the students were reading ahead but did not fully understand what they were reading. He wrote: "*Students seemed not to know about the symbols used in drawing electric circuits. However the teacher helped them out.*"

Problems of poor achievement in math and the sciences among students who learn by using their second language versus their native tongue has been directly correlated with deficiencies in English writing skills (Mayaba, Otterup, and Webb, 2013). Hence, such students have a hard time properly acquiring clearer writing skills (ibid.). On the other hand, feedback from students in Group A shows that the approach used in this study inadvertently did encourage them to read and write.

Greenstein, (2013), Cleland, Rillero, and Zambo (2003), Dobyns & Lewis (2001) have reported on the positive impact of writing on students. It has been found to encourage the reading of class notes and textbooks, to encourage thinking, encourage a focus on retention, and encouraging participation in class. As an example, Teacher A reported that after the prompt "*Explain in a scientific way how lightning occurs,*" students "*became interesting when students asked questions about facts and myths about lightening.*"

The summary results from the experimental group showed the following at the mid-point of the study: About 88.9% (n = 48/54) of students found the activity to be a positive experience. One student reported the activity as a negative experience and 9.3% (n = 5/54) were not present to provide feedback at the time.

Post-study feedback showed that 75.93% (n = 41/54) of students found the activity to be a positive experience. While 3.70% (n = 2/54) of students reported the activity as being negative, 5.56% (n = 3/54) reported the activity as both positive and negative, and 11.11% (n = 6/54) were not present to provide feedback at this time.

## Chapter 5: Conclusions and Recommendations

Students did make gains between pre and post-tests. However, the test data did not confirm the hypothesis that students using quick-write prompts would gain in knowledge more than those who were not using this method. The analysis of teachers' journal writings indicated that the control group of students felt motivated by the instructional strategies more so than the experimental group. Not only that, there was evidence that students were taking the time to read ahead, in anticipation of quick-write prompts. Furthermore, the uses of the questions increased student participation through questions and discussions. These are all good indicators of success towards creating a positive learning environment.

Research findings from the United States, suggest that instruction of the type that were used in this study can be beneficial to groups of learners with diverse learning capacities and across subject areas. Research indicates that benefits may increase if the duration of the experience is extended more than was the case in this study of four weeks (Cleland, Rillero, and Zambo, 2003; Dobyns and Lewis, 2001; Rillero, Zambo, Cleland, and Ryan, 1996; Rivard, 1994).

Students who are typically taught throughout their lives to believe that all questions must have a particular right answer tend to not adjust well to answering questions or statements that have no right or wrong answer (Dobyns and Lewis, 2001). It is my belief that this has for years been the case for Basotho students. Problems of poor achievement in the math and sciences among students that learn by using their second language versus their native tongue(s) has been directly correlated with deficiencies in English writing skills, thus not easily allowing for needed writing skills to be properly acquired (Mayaba, Otterup, and Webb, 2013). Nevertheless, Basotho children normally and understandably lack self-confidence in their abilities with the English language thus in science as well. As their second language, it must be learned in school amidst the predominant native Sesotho language. This, in turn, hinders even more their ability to answer these kinds of questions.

The challenge for all teachers is to promote a positive and thought-provoking environment in the classroom which can help ease students fears and worries with assessments. Doing so can be achieved by carrying out both formal and informal evaluation techniques in such a way that both stimulate and respect the views of all students.

The Peace Corps Volunteer who preceeded my service in Renekeng Secondary School was impressed and highly interested in adapting this method into her mathematics teaching for the duration of her service. She also intends to model the use of this method to the current Basotho teachers at the school in hopes of encouraging and motivating them to allow this method to enrich their teaching skills and subsequently enrich Renekeng's student performance in a variety of subject areas.

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## <u>Appendix A</u>: Pre-Assessment / Pre-Test

Age: _________ ID: _________

Sex: _________ Village of residence: ____________________

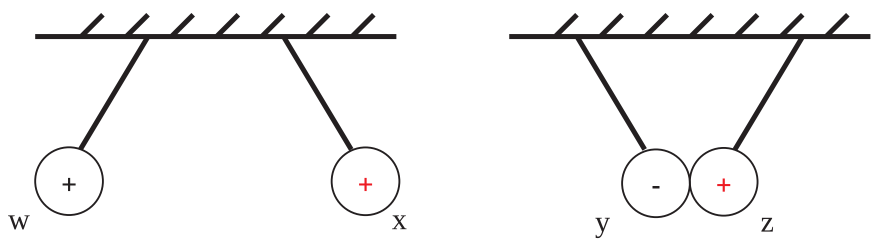
FORM B SCIENCE PRE-ASSSESSMENT
TIME: 1 hour MARKS: 35

<u>INSTRUCTIONS</u>: Please do not write your name. Instead, provide your age, sex (Male or Female), village of current residence, and assigned ID (letter & number) at the top of this paper. *Thank You! (Kea Leboha)*

**Read each question carefully and try your best to provide an educated answer.**

<u>Question I</u>: Static Electricity

a) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings.




i) What observations are made between: [**2 marks**]

a. 'w' and 'x':

- Repel each other (1 mark)

b. 'y' and 'z':

- Attract each other (1 mark)

ii) Complete the diagram to show the type of charges on balls 'x' and 'z'. [**2 marks;** '+' (1 mark) and '+' (1 mark)]

iii) Why is the observed behavior of the balls occurring? [**2 marks**]

- Same charge (+) in 'w' and 'x' (1 mark)
- Unlike charges (-) and (+) in 'y' and 'z' (1 mark)

Or

- Like charges repel (1 mark)
- Unlike charges attract (1 mark)

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

(1) Charged material is brought close to the cap of the electroscope and charges it by induction either positively or negatively depending on charge in the material (1 mark).

(2) Charge is distributed completely to brass rod and gold leaf. Due to like charges, gold leaf deflects trying to repel from brass rod (1 mark).

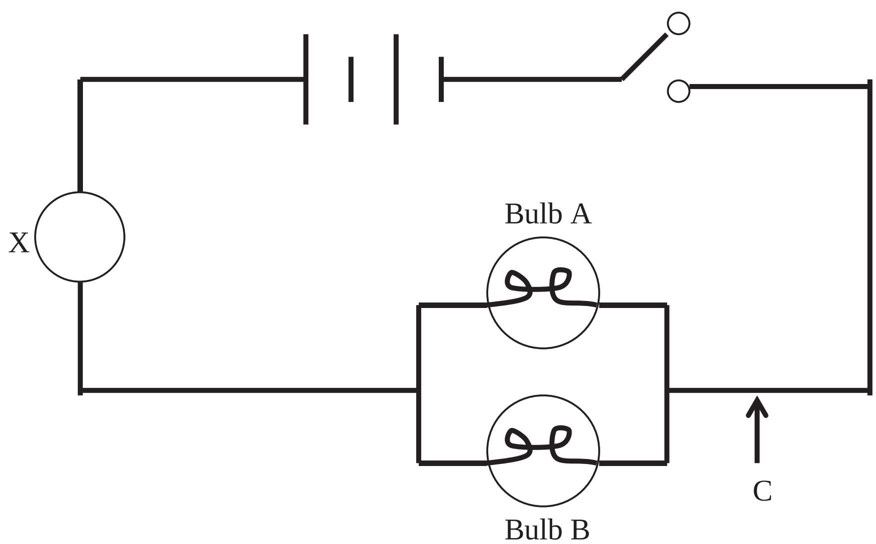
(3) To make it neutral, touch the cap with a finger (1 mark).

ii) What is the function of a gold leaf electroscope? [**2 marks**]

- To test for the presence of charge (1 mark) and to test the type of charge present (1 mark).

<u>Question II</u>: Current Electricity

a) The diagram below shows an electrical circuit.




i. Name the instrument that could be installed at ‘ X ‘ and state its purpose. [**2 marks**]

- Name: Ammeter (1 mark)
- Purpose: Measures amount of current flowing in a circuit (1 mark).

ii. How will the addition of a third bulb in location ‘ C ‘ affect the brightness of Bulb ‘A’ and Bulb ‘B’? [**2 marks**]

- Bulb ‘A’: Brightness decreases (1 mark).

- Bulb ‘B’: Brightness decreases (1 mark).

iii. If one cell is added in series, how will this affect the brightness of the bulbs? [**1 mark**]

- Brightness will increase (1 mark).

iv. What is the disadvantage of connecting streetlights in series? [**2 marks**]

- If one bulb breaks or burns out, the circuit is disconnected (1 mark) and no light is observed (1 mark).

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

- Connect the street light bulbs in parallel (1 mark).

<u>Question III</u>: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

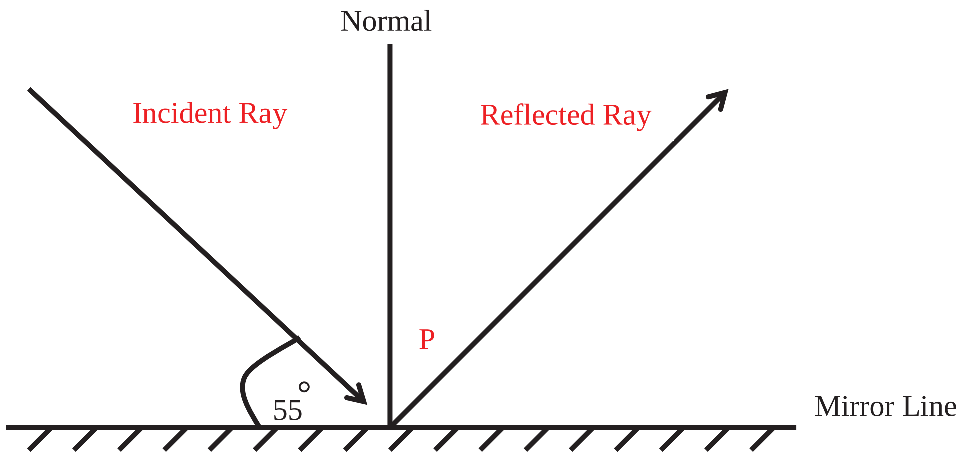
a) Give one difference between light waves and sound waves. [**1 mark**]

- Light waves are transverse in nature, while sound waves are longitudinal (1 mark)
- Light waves can travel in a vacuum, while sound waves cannot (1 mark)
- Light waves travel at a speed of 3 x 10^8 m/s, while sound waves travel with a speed of 340 m/s (1 mark)
- Light waves do not require a medium in order to travel, while sound waves do require a medium in order to travel (1 mark)

b) Name one instrument that functions with the use of light. [**1 mark**]

- Camera, microscope, binoculars, telescope, etc. (1 mark for 1 right answer)

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ' P ' on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

- P = 90º - 55º (1 mark) = 35º (1 mark)

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

- 1 mark for each proper label

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? [**3 marks**]

- Speed = distance traveled / time taken = 3,708 kilometers / 3 hours (1 mark) = 1, 236 (1 mark) km/hr (1 mark)
- Or 3,708,000 meters / 10,800 seconds (1 mark) = 343.3 (1 mark) m/s (1 mark)

e) At what speed do electromagnetic waves travel? [**1 mark**]

- Speed of light (1 mark) or 3 x 10^8 m/s (1 mark)

f) Give an example of an electromagnetic wave that is not a light wave (not sun rays). [**1 mark**]

- Any of the following (1 mark): Radio waves, Ultraviolet (UV), Infrared (IR), X-rays, Gamma rays, Microwaves

Question IV: Chemistry of Water

The diagram below shows the stages in the purification of water at a large scale:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank ↓ Return to river

a) State examples of substances that can be removed in the screening tank. [**1 mark**]

- Large bits of rubbish like plastics, wood materials, etc. (1 mark)

b) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

- Small particles of sand and small stones (1 mark)

c) What is the purpose of the chlorination tank? [**1 mark**]

- To kill the germs in water (1 mark)

d) Give one difference between hard water and soft water. [**2 marks**]

- Hard water contains calcium (Ca) (1/2 mark) and magnesium (Mg) (1/2 mark) ions, while soft water does not (1 mark).

**<u>Appendix B</u>: Post-Assessment / Post-test**
(Key is the same as Pre-Assessment / Test)

Age (in years): _________ ID: _________

Sex (Male or Female): _________ Village of residence: ____________________

FORM B SCIENCE POST-ASSSESSMENT
TIME: 1 hour MARKS: 35

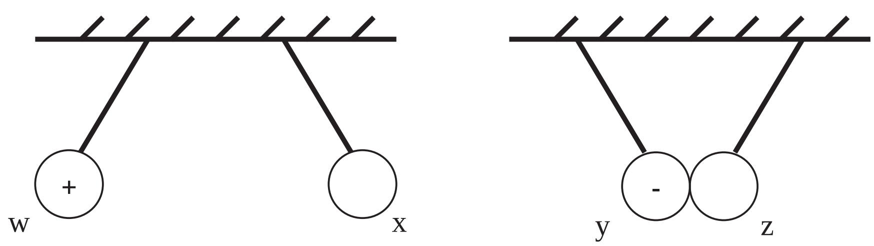
<u>INSTRUCTIONS</u>: Please do not write your name. Instead, provide your age in years, sex (Male or Female), village of current residence at the top of this paper.

*Thank You! (Kea Leboha)*

**Read each question carefully and try your best to give your best answer.**

<u>Question I</u>: Static Electricity

b) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings. Complete the diagram below, within the empty grey shaded regions, to show the type of charges on balls ‘x’ and ‘z’. [**2 marks**]




iv) What scientific observations can you make between: [**2 marks**]

a. ‘w’ and ‘x’:

b. ‘y’ and ‘z’:

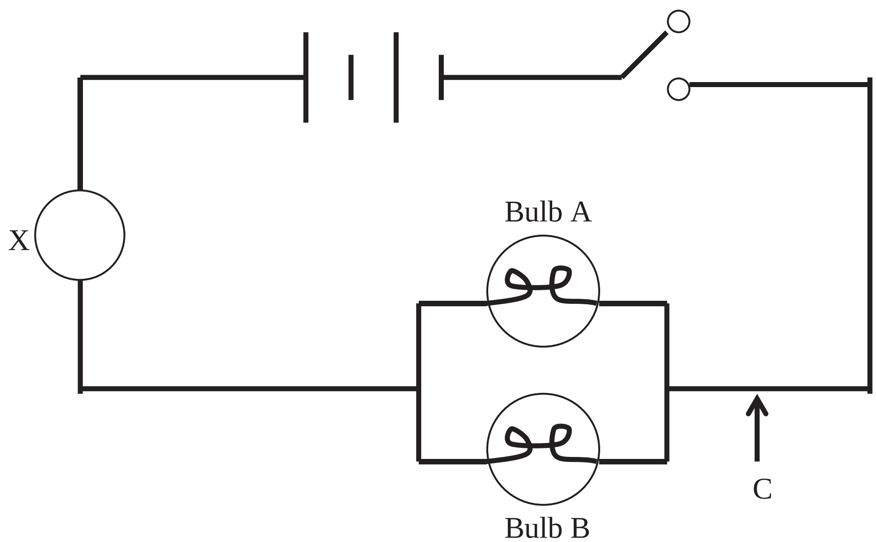
v) Why is the observed behavior of the balls occurring? [**2 marks**]

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

i) What is the function of a gold leaf electroscope? [**2 marks**]

<u>Question II</u>: Current Electricity

b) The diagram below shows an electrical circuit.




i. Name the instrument that could be installed within the shaded region labeled ‘X‘ and state its purpose. [**2 marks**]

ii. How will the addition of a third light bulb in location ‘ C ‘ on the electrical circuit diagram affect the brightness of Bulb ‘A’ and Bulb ‘B’? [**2 marks**]

iii. If one cell is added in series, how will this affect the brightness of all the bulbs in the circuit? [**1 mark**]

iv. With regard to electrical circuitry, what is the disadvantage of connecting streetlights in series? [**2 marks**]

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

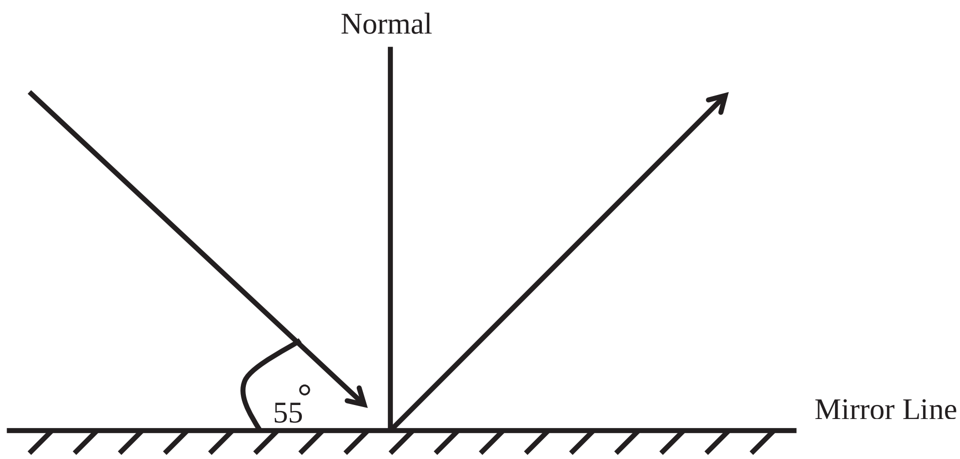
<u>Question III</u>: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

a) Give one difference between light waves and sound waves. [**1 mark**]

b) Name one instrument (apparatus) that functions with the use of light. [**1 mark**]

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ‘ P ‘ on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? Remember to include the appropriate units. [**3 marks**]

e) At what speed do electromagnetic waves travel? Remember to include the appropriate units. [**1 mark**]

f) Provide an example of an electromagnetic wave. You may NOT use “light wave “ nor “sun rays” as your example. [**1 mark**]

<u>Question IV</u>: Chemistry of Water

The diagram below shows the stages of large-scale purification for non-drinkable sewage water that will be returned to a river environment:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank ↓ Return to river

e) State examples of substances that can be removed in the screening tank. [**1 mark**]

f) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

g) What is the purpose of the chlorination tank? [**1 mark**]

h) Give one difference between hard water and soft water. [**2 marks**]

## Appendix C: Prompted Quick-Write Questions and Statements

*Static Electricity*

- If we had electricity in our homes, how would it help improve our lives? (Oct. 15, 2013)
- Explain in a scientific way how lightning occurs. (Oct. 16, 2013)
- Which kinds of tools do scientists use and why are tools important to scientists? Describe some of the tools scientists use. (Oct. 17, 2013)
- If scientists did not have tools to use, how would this affect their work? (Oct. 18, 2013)

*Current Electricity*

- List materials that allow electrons to be transmitted. (Oct. 21, 2013.
- Suppose you were given a piece of copper wire, a cell battery, and a light bulb. Show with the use of a drawing how you would connect these materials together in order to make the bulb light. (Oct. 22, 2013)
- Pretend you are a spark of electricity. Explain your journey from an energy resource to your mobile phone, television, or any other electrical instrument you know of. (Oct. 23, 2013)

*Mid-Study Feedback*

- Write anything you would like to express your opinion and/or provide any recommendations on your participation and the use of this activity. (Same day as Oct. 23, 2013 during a study period)

*Chemistry of Water*

- Describe in detail your favorite solvent. (Oct. 24, 2013)
- Why do you think solid water or ice floats within liquid water? (Oct. 28, 2013)
- Explain how you would purify river water at home to make it safe to drink? (Oct. 29, 2013)

*Electromagnetic Waves*

- When an airplane flies in the sky above, you see it before you can hear it.  Why do you think this happens?  (Oct. 30, 2013)
- Why do you think electromagnetic waves are good and also dangerous to us? (Oct. 31, 2013)
- How would you protect yourself from the sun's rays during the summer time? (Nov. 4, 2013)
- It appears that dogs can hear sounds better than human beings.  Explain why you think this happens. (Nov. 5, 2013)

*Post-Study Feedback*

- Write anything you would like to express your opinion and/or provide any recommendations on your participation and the use of this activity. (Nov. 6, 2013)

**Appendix D: Group A - Results and Statistical Data**

| Participant | Pre-Test Results | Post-test Results | Group A Gains |
|---|---|---|---|
| 1 | 12 | 10 | -2 |
| 2 | 3 | 6 | 3 |
| 3 | 11 | 25 | 14 |
| 4 | 9 | 21.5 | 12.5 |
| 5 | 6 | 7 | 1 |
| 6 | 3 | 11.5 | 8.5 |
| 7 | 12 | 19 | 7 |
| 8 | 1 | 1 | 0 |
| 9 | 3 | 8 | 5 |
| 10 | 4 | 5 | 1 |
| 11 | 1 | 9 | 8 |
| 12 | 5 | 17 | 12 |
| 13 | 10 | 15 | 5 |
| 14 | 9 | 12.5 | 3.5 |
| 15 | 0 | 2 | 2 |
| 16 | 12 | 14 | 2 |
| 17 | 3 | 11.5 | 8.5 |
| 18 | 13 | 23 | 10 |
| 19 | 7 | 12 | 5 |
| 20 | 10 | 11 | 1 |
| 21 | 4 | 14 | 10 |
| 22 | 0 | 7 | 7 |
| 23 | 15 | 18.5 | 3.5 |
| 27 | 10 | 23 | 13 |
| 28 | 2 | 12 | 10 |
| 29 | 14 | 16 | 2 |
| 30 | 8 | 12.5 | 4.5 |
| 31 | 5 | 10 | 5 |
| 32 | 8 | 11 | 3 |
| 34 | 5 | 9 | 4 |
| 35 | 12 | 19.5 | 7.5 |
| 36 | 1 | 4 | 3 |
| 37 | 1 | 11 | 10 |
| 38 | 7 | 11 | 4 |
| 39 | 12 | 20 | 8 |
| 40 | 9 | 22 | 13 |
| 41 | 4 | 9 | 5 |
| 42 | 14 | 25 | 11 |
| 43 | 2 | 10 | 8 |
| 44 | 8 | 17 | 9 |
| 45 | 6 | 14 | 8 |
| 46 | 2 | 11 | 9 |
| 47 | 14 | 22 | 8 |
| 48 | 7 | 8 | 1 |

| | | | |
|---|---|---|---|
| 49 | 9 | 13 | 4 |
| 50 | 6.5 | 11 | 4.5 |
| 51 | 6 | 17 | 11 |
| 52 | 1 | 7 | 6 |
| 53 | 2 | 4 | 2 |
| 54 | 8 | 20 | 12 |
| 55 | 8 | 20 | 12 |
| | | | |
| N (Participants) = | 51 | 51 | 51 |
| Average (Mean %) = | 6.754901961 | 13.12745098 | 6.37254902 |
| Standard Deviation (Variance) = | 4.282957563 | 6.074407903 | 3.997303012 |
| | | | |
| t-test (*p* value of 0.05) = | 8.56024E-16 | | |

**Appendix E:** **Group B - Results and Statistical Data**

| Participant | Pre-Test Group B | Post-test Group B | Group B Gains |
|---|---|---|---|
| 1 | 5 | 18 | 13 |
| 2 | 5 | 12 | 7 |
| 3 | 8 | 12 | 4 |
| 4 | 12 | 22 | 10 |
| 5 | 5 | 13 | 8 |
| 6 | 2 | 5 | 3 |
| 7 | 3 | 20 | 17 |
| 8 | 3 | 3 | 0 |
| 9 | 4 | 6 | 2 |
| 10 | 6 | 11 | 5 |
| 11 | 7 | 13 | 6 |
| 12 | 2 | 8 | 6 |
| 13 | 2 | 7 | 5 |
| 15 | 3 | 5 | 2 |
| 16 | 3 | 15 | 12 |
| 17 | 5 | 20 | 15 |
| 18 | 3 | 17 | 14 |
| 19 | 1 | 13 | 12 |
| 20 | 5 | 13 | 8 |
| 22 | 7 | 15.5 | 8.5 |
| 23 | 4 | 10 | 6 |
| 24 | 8 | 19 | 11 |
| 25 | 2 | 7 | 5 |
| 26 | 6 | 13 | 7 |
| 27 | 8 | 19.5 | 11.5 |
| 28 | 12 | 16 | 4 |
| 29 | 0 | 9 | 9 |
| 30 | 6 | 8 | 2 |
| 31 | 11 | 17.5 | 6.5 |
| 32 | 4 | 7 | 3 |
| 33 | 5 | 9.5 | 4.5 |
| 35 | 0 | 9.5 | 9.5 |
| 36 | 5 | 9 | 4 |
| 37 | 0 | 5 | 5 |
| 38 | 4 | 11 | 7 |
| 39 | 7 | 18 | 11 |
| 40 | 2 | 7 | 5 |
| 41 | 6 | 17 | 11 |
| 42 | 2 | 8 | 6 |
| 43 | 1 | 7 | 6 |
| 46 | 4 | 10 | 6 |
| 47 | 1 | 11 | 10 |
| 48 | 6 | 19 | 13 |
| | | | |

| | | | |
|---|---|---|---|
| N (Total Participants) = | 43 | 43 | 43 |
| Average (Mean %) = | 4.534883721 | 11.98837209 | 7.453488372 |
| Standard Deviation (Variance) = | 2.9708812 | 5.012470606 | 3.91093393 |
| | | | |
| t-test (*p* value of 0.05) = | 4.85019E-16 | | |

**<u>Appendix F</u>: Group A vs. Group B Gains t-test**

| Group A Gains | Group B Gains |
|---|---|
| -2 | 13 |
| 3 | 7 |
| 14 | 4 |
| 12.5 | 10 |
| 1 | 8 |
| 8.5 | 3 |
| 7 | 17 |
| 0 | 0 |
| 5 | 2 |
| 1 | 5 |
| 8 | 6 |
| 12 | 6 |
| 5 | 5 |
| 3.5 | 2 |
| 2 | 12 |
| 2 | 15 |
| 8.5 | 14 |
| 10 | 12 |
| 5 | 8 |
| 1 | 8.5 |
| 10 | 6 |
| 7 | 11 |
| 3.5 | 5 |
| 13 | 7 |
| 10 | 11.5 |
| 2 | 4 |
| 4.5 | 9 |
| 5 | 2 |
| 3 | 6.5 |
| 4 | 3 |
| 7.5 | 4.5 |
| 3 | 9.5 |
| 10 | 4 |
| 4 | 5 |
| 8 | 7 |
| 13 | 11 |
| 5 | 5 |
| 11 | 11 |
| 8 | 6 |
| 9 | 6 |
| 8 | 6 |
| 9 | 10 |
| 8 | 13 |
| 1 | |
| 4 | |

| | | |
|---|---|---|
| 4.5 | | |
| 11 | | |
| 6 | | |
| 2 | | |
| 12 | | |
| 12 | | |
| | | |
| N (Total Participants) = | 51 (A) | 43 (B) |
| Average (Mean) = | 6.37254902 | 7.453488372 |
| Standard Deviation (Variance) = | 3.997303012 | 3.91093393 |
| | | |
| t-test (*p* value of 0.095) = | 0.095209081 | |

**<u>Appendix G</u>: Groups A & B Pre-Test and t-test Results**

| Pre-Test Group A | Pre-Test Group B |
|---|---|
| 12 | 5 |
| 3 | 5 |
| 11 | 8 |
| 9 | 12 |
| 6 | 5 |
| 3 | 2 |
| 12 | 3 |
| 1 | 3 |
| 3 | 4 |
| 4 | 6 |
| 1 | 7 |
| 5 | 2 |
| 10 | 2 |
| 9 | 3 |
| 0 | 3 |
| 12 | 5 |
| 3 | 3 |
| 13 | 1 |
| 7 | 5 |
| 10 | 7 |
| 4 | 4 |
| 0 | 8 |
| 15 | 2 |
| 10 | 6 |
| 2 | 8 |
| 14 | 12 |
| 8 | 0 |
| 5 | 6 |
| 8 | 11 |
| 5 | 4 |
| 12 | 5 |
| 1 | 0 |
| 1 | 5 |
| 7 | 0 |
| 12 | 4 |
| 9 | 7 |
| 4 | 2 |
| 14 | 6 |
| 2 | 2 |
| 8 | 1 |
| 6 | 4 |
| 2 | 1 |
| 14 | 6 |
| 7 | |
| 9 | |

| | | |
|---|---|---|
| 6.5 | | |
| 6 | | |
| 1 | | |
| 2 | | |
| 8 | | |
| 8 | | |
| | | |
| N (Total Participants) = | 51 (A) | 43 (B) |
| Average (Mean) = | 6.754901961 | 4.534883721 |
| Standard Deviation (Variance) = | 4.282957563 | 2.9708812 |
| | | |
| t-test (*p* value of 0.095) = | 0.002576282 | |

**<u>Appendix H</u>: Form A & B Repeaters vs. Non-Repeaters Post-test and t-test Results**

| Form A & B **Repeating** (R) Students | | Form A & B **Non-Repeating** (Non-R) Students | |
|---|---|---|---|
| Participant | Post-test Score | Participant | Post-test Score |
| A1 | 10 | A2 | 6 |
| A8 | 1 | A3 | 25 |
| A13 | 15 | A4 | 21.5 |
| A14 | 12.5 | A5 | 7 |
| A15 | 2 | A6 | 11.5 |
| A16 | 14 | A7 | 19 |
| A20 | 11 | A9 | 8 |
| A21 | 14 | A10 | 5 |
| A23 | 18.5 | A11 | 9 |
| A27 | 23 | A12 | 17 |
| A28 | 12 | A17 | 11.5 |
| A35 | 19.5 | A18 | 23 |
| A37 | 11 | A19 | 12 |
| A40 | 22 | A22 | 7 |
| A43 | 10 | A29 | 16 |
| A46 | 11 | A30 | 12.5 |
| A47 | 22 | A31 | 10 |
| A48 | 8 | A32 | 11 |
| A54 | 20 | A34 | 9 |
| B2 | 12 | A36 | 4 |
| B13 | 7 | A38 | 11 |
| B15 | 5 | A39 | 20 |
| B23 | 10 | A41 | 9 |
| B38 | 11 | A42 | 25 |
| B41 | 17 | A44 | 17 |
| B42 | 8 | A45 | 14 |
| | | A49 | 13 |
| | | A50 | 11 |
| | | A51 | 17 |
| | | A52 | 7 |
| | | A53 | 4 |
| | | A55 | 20 |
| | | B1 | 18 |
| | | B3 | 12 |
| | | B4 | 22 |
| | | B5 | 13 |
| | | B6 | 5 |
| | | B7 | 20 |
| | | B8 | 3 |
| | | B9 | 6 |

| | | | |
|---|---|---|---|
| | | B10 | 11 |
| | | B11 | 13 |
| | | B12 | 8 |
| | | B16 | 15 |
| | | B17 | 20 |
| | | B18 | 17 |
| | | B19 | 13 |
| | | B20 | 13 |
| | | B22 | 15.5 |
| | | B24 | 19 |
| | | B25 | 7 |
| | | B26 | 13 |
| | | B27 | 19.5 |
| | | B28 | 16 |
| | | B29 | 9 |
| | | B30 | 8 |
| | | B31 | 17.5 |
| | | B32 | 7 |
| | | B33 | 9.5 |
| | | B35 | 9.5 |
| | | B36 | 9 |
| | | B37 | 5 |
| | | B39 | 18 |
| | | B40 | 7 |
| | | B43 | 7 |
| | | B46 | 10 |
| | | B47 | 11 |
| | | B48 | 19 |
| | | | |
| N (Total Participants) = | | 26 (R) | 68 (Non-R) |
| Average (Mean %) = | | 12.5576923 | 12.625 |
| Standard Deviation (Variance) = | | 5.86741327 | 5.5579545 |
| | | | |
| t-test (*p* value of 0.05) = | | 0.47943114 | |

## Appendix I: Participating Teacher Profiles

### *Experimental (Group A) Teacher Profile*

- Age: 49
- Sex: Male
- Village of current residency: Adjacent village of Ha Rantuba
- Certified and qualified to teach by the Lesotho College of Education.
- 8 years teaching the Ministry of Education's Form B science curriculum.
- 26 years of teaching experience.
- 7 years as a Renekeng Secondary School teaching staff member.
- For the last 5 years, the teacher reported to have had more than a 50% passing rate in Form B science; 2008 (53%), 2009 (76%), 2010 (82%), 2011 (73%), and 2012 (90%).
- Teacher did not develop detailed daily lesson plans, but rather provided daily summaries of each lesson with his reflections in his teaching journal.

### *Control (Group B) Teacher Profile*

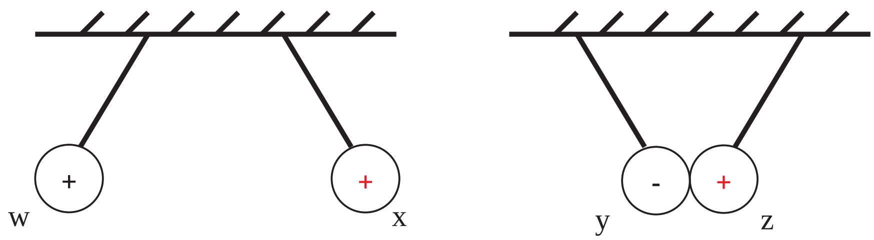
- Age: 28
- Sex: Male
- Village of current residency: Adjacent village of Lihlabeng.
- Certified and qualified to teach by the Lesotho College of Education.
- 2 years teaching the Ministry of Education's Form B science curriculum.
- 2 years of teaching experience.
- 2 years as a Ralikariki High School teaching staff member.
- For the last 2 years, the teacher reported to have had a $\geq$ 45% passing rate in Form B science.
- Teacher developed detailed daily lesson plans (e.g. Class, Class Size, Subject,

Topic, Date, Time, Duration, Objective(s), Teaching Methods, Teaching Materials, Introduction, Lesson Development – content, Teachers Activity, Learners Activity, Conclusion, and Evaluation) with remarks on the outcomes of each and also kept a daily teaching journal.

## Appendix J: Experimental Group A Pre-Assessment Results (N=51/55)

Question I: Static Electricity

a) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings.




- Answer: 'X' is (+)
- Partial Credit: 11/55 (20%)

Answer: 'Z' is (+)
Partial Credit: 20/55 (36%)

- Full Credit (Both 'X' & 'Z'): 9/55 (16%)
- Did not attempt 'X' nor 'Z': 35/55 (63.6%)

i) What observations are made between: [**2 marks**]

a. 'w' and 'x':

- Answer: Repel each other (1 mark)
  - Full Credit: 27/55 (49%)
  - Did not attempt: 2/55 (3.6%)

b. 'y' and 'z':

- Answer: Attract each other (1 mark)
  - Full Credit: 27/55 (49%)
  - Did not attempt: 2/55 (3.6%)

ii) Complete the diagram to show the type of charges on balls 'x' and 'z'. [**2 marks;** '+' (1 mark) and '+' (1 mark)] *15/55 wrote answers in this section.

iii) Why is the observed behavior of the balls occurring? [**2 marks**]

- Answers:
  - Same charge (+) in 'w' and 'x' (1 mark)
  - Unlike charges (-) and (+) in 'y' and 'z' (1 mark)

Or

  - Like charges repel (1 mark)
  - Unlike charges attract (1 mark)

- Full Credit: 4/55 (7%)
- Partial Credit:
    - Unlike charges attract: 4/55 (7%)
- Did not attempt: 15/55 (27%)

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

Answers:

(1) Charged material is brought close to the cap of the electroscope and charges it by induction either positively or negatively depending on charge in the material (1 mark).

(2) Charge is distributed completely to brass rod and gold leaf. Due to like charges, gold leaf deflects trying to repel from brass rod (1 mark).

(3) To make it neutral, touch the cap with a finger (1 mark).

- Full Credit: 0/55 (0%)
- Partial Credit: 0/55 (0%)
- Did not attempt: 19/55 (34.5%)

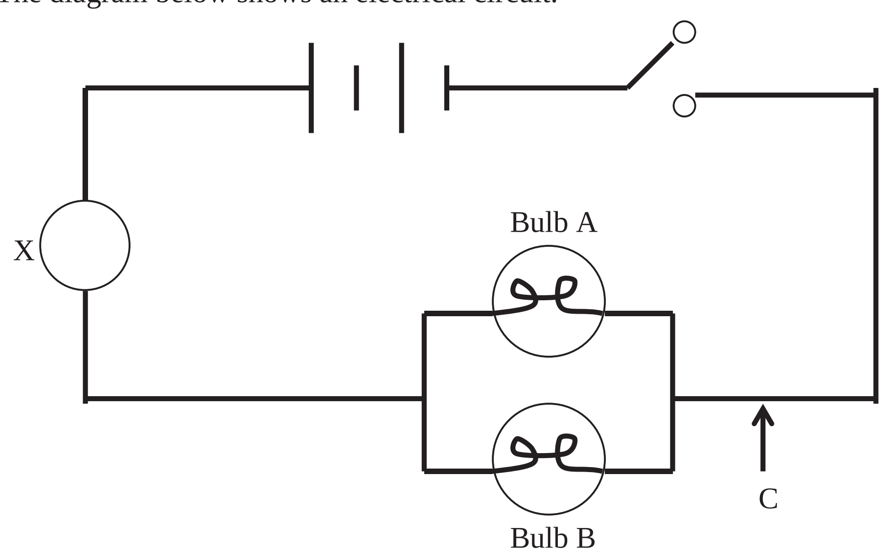
i) What is the function of a gold leaf electroscope? [**2 marks**]

- Answer:
- To test for the presence of charge (1 mark) and to test the type of charge present (1 mark).

- Full Credit: 0/55 (0%)
- Partial Credit: 0/55 (0%)
- Did not attempt: 11/55 (20%)

Question II: Current Electricity

a) The diagram below shows an electrical circuit.



i. Name the instrument that could be installed at ' X ' and state its purpose. [**2 marks**]

- Answer:
  - Name: Ammeter (1 mark)
  - Purpose: Measures amount of current flowing in a circuit (1 mark)

  - Full Credit: 0/55 (0%)
  - Partial Credit:
    - Name: 4/55 (7%)
    - Purpose: 3/55 (5%)
  - Did not attempt: 5/55 (9%)

ii. How will the addition of a third bulb in location ' C ' affect the brightness of Bulb 'A' and Bulb 'B'? [**2 marks**]

- Answer:
  - Bulb 'A': Brightness decreases (1 mark)
  - Bulb 'B': Brightness decreases (1 mark)

  - Full Credit: 3/55 (5%)
  - Partial Credit: 0/55 (0%)
  - Did not attempt: 9/55 (16%)

iii. If one cell is added in series, how will this affect the brightness of the bulbs? [**1 mark**]

- Answer:
  - Brightness will increase (1 mark)

  - Full Credit: 7/55 (12.7%)
  - Did not attempt: 5/55 (9%)

iv. What is the disadvantage of connecting streetlights in series? [**2 marks**]

- Answer:
  - If one bulb breaks or burns out, the circuit is disconnected (1 mark) and no light is observed (1 mark).

  - Full Credit: 2/55 (3.6%)
  - Partial Credit: 0/55 (0%)
  - Did not attempt: 6/55 (10.9%)

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

- Answer:
  - Connect the street light bulbs in parallel (1 mark)

  - Full Credit: 1/55 (1.8%)
  - Did not attempt: 17/55 (30.9%)

Question III: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

a) Give one difference between light waves and sound waves. [**1 mark**]

- Possible Answers:
  - Light waves are transverse in nature, while sound waves are longitudinal (1 mark)
  - Light waves can travel in a vacuum, while sound waves cannot (1 mark)
  - Light waves travel at a speed of 3 x 10^8 m/s, while sound waves travel with a speed of 340 m/s (1 mark)
  - Light waves do not require a medium in order to travel, while sound waves do require a medium in order to travel (1 mark)

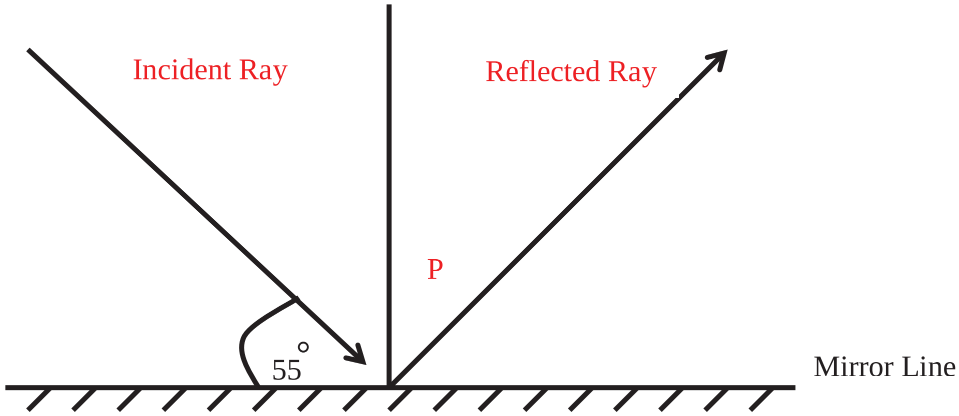
  - Full Credit: 5/55 (9%)
  - Partial Credit: 0/55 (0%)
  - Did not attempt: 4/55 (7%)

b) Name one instrument that functions with the use of light. [**1 mark**]

- Possible Answers:
  - Camera, microscope, binoculars, telescope, etc. (1 mark for 1 right answer)

  - Full Credit: 0/55 (0%)
  - Did not attempt: 5/55 (9%)

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ' P ' on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

- Answer:
- P = 90º - 55º (1 mark) = 35º (1 mark)

- Full Credit: 9/55 (16%)
- Did not attempt: 13/55 (23.6%)

- Labeling:
    - 'P':
        - Full Credit: 15/55 (27%)
        - Did not attempt: 11/55 (20%)

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

- Answer:
- 1 mark for each proper label
    - Incident Ray:
        - Full Credit: 20/55 (36%)
        - Did not attempt: 21/55 (38%)
    - Reflected Ray:
        - Full Credit: 23/55 (41.8%)
        - Did not attempt: 18/55 (32.7%)

*5/55 did not label, but wrote wrong answers under this section.

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? [**3 marks**]

- Possible Answers:
    - Speed = distance traveled / time taken = 3,708 kilometers / 3 hours (1 mark) = 1, 236 (1 mark) km/hr (1 mark)
    - Or 3,708,000 meters / 10,800 seconds (1 mark) = 343.3 (1 mark) m/s (1 mark)

    - Full Credit: 14/55 (25%)
    - Partial Credit:
        - 3,708 km / 3 hrs: 2/55 (3.6%)
        - 3, 708 km / 3 hrs = 1, 236: 9/55 (16%)
    - Did not attempt: 6/55 (10.9%)

e) At what speed do electromagnetic waves travel? [**1 mark**]

- Possible Answers:
    - Speed of light (1 mark) or 3 x 10^8 m/s (1 mark)

    - Full Credit: 1/55 (1.8%)
    - Did not attempt: 9/55 (16%)

f) Give an example of an electromagnetic wave that is not a light wave (not sun rays). [**1 mark**]

- Possible Answer:
    - Any of the following (1 mark): Radio waves, Ultraviolet (UV), Infrared (IR), X-rays, Gamma rays, Microwaves

    - Full Credit: 3/55 (5%)
    - Did not attempt: 6/55 (10.9%)

Question IV: Chemistry of Water

The diagram below shows the stages in the purification of water at a large scale:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank ↓ Return to river

a) State examples of substances that can be removed in the screening tank. [**1 mark**]

- Possible Answer:
    - Large bits of rubbish like plastics, wood materials, etc. (1 mark)

    - Full Credit: 7/55 (12.7%)
    - Did not attempt: 1/55 (1.8%)

b) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

- Answer:
    - Small particles of sand and small stones (1 mark)

    - Full Credit: 14/55 (25%)
    - Did not attempt: 3/55 (5%)

c) What is the purpose of the chlorination tank? [**1 mark**]

- Answer:
    - To kill the germs in water (1 mark)

    - Full Credit: 29/55 (52.7%)
    - Did not attempt: 2/55 (3.6%)

d) Give one difference between hard water and soft water. [**2 marks**]

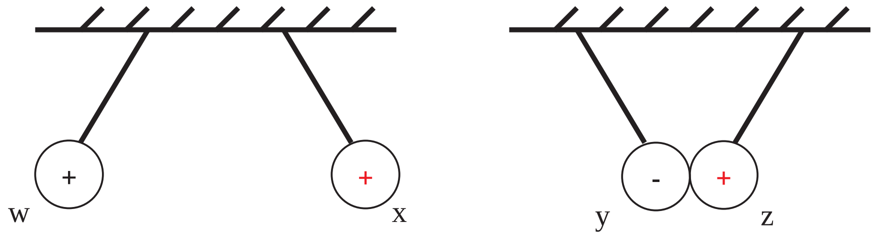
- Answer:
    - Hard water contains calcium (Ca) (1/2 mark) and magnesium (Mg) (1/2 mark) ions, while soft water does not (1 mark).

    - Full Credit: 9/55 (16%)
    - Partial Credit: 0/55 (0%)
    - Did not attempt: 9/55 (16%)

## Appendix K: Control Group B Pre-Assessment Results (N=47/50)

Question I: Static Electricity

a) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings.




- Answer: 'X' is (+)
- Partial Credit: 2/50 (4%)

Answer: 'Z' is (+)
Partial Credit: 10/50 (18%)

- Full Credit (Both 'X' & 'Z'): 6/50 (12%)
- Did not attempt 'X' nor 'Z': 39/50 (78%)

i) What observations are made between: [**2 marks**]

a. 'w' and 'x':

- Answer: Repel each other (1 mark)
  - Full Credit: 25/50 (50%)
  - Did not attempt: 1/50 (2%)

b. 'y' and 'z':

- Answer: Attract each other (1 mark)
  - Full Credit: 30/50 (60%)
  - Did not attempt: 3/50 (6%)

ii. Complete the diagram to show the type of charges on balls 'x' and 'z'. [**2 marks;** '+' (1 mark) and '+' (1 mark)] *11/50 wrote answers in this section.

iii. Why is the observed behavior of the balls occurring? [**2 marks**]

- Answers:
  - Same charge (+) in 'w' and 'x' (1 mark)
  - Unlike charges (-) and (+) in 'y' and 'z' (1 mark)

Or

  - Like charges repel (1 mark)
  - Unlike charges attract (1 mark)

- Full Credit: 4/50 (8%)
- Partial Credit:
    - Same charge (+) ‘w’ & ‘z’: 2/50 (4%)
    - Like charges repel: 1/50 (2%)
    - Unlike charges attract: 3/50 (6%)
    - “Static electricity”: 1/50 (2%)
    - “They are charged”: 3/50 (6%)

- Did not attempt: 12/50 (21.8%)

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

Answers:

(1) Charged material is brought close to the cap of the electroscope and charges it by induction either positively or negatively depending on charge in the material (1 mark).

(2) Charge is distributed completely to brass rod and gold leaf. Due to like charges, gold leaf deflects trying to repel from brass rod (1 mark).

(3) To make it neutral, touch the cap with a finger (1 mark).

- Full Credit: 0/50 (0%)
- Partial Credit:
    - (1): 2/50 (4%)
- Did not attempt: 9/50 (18%)

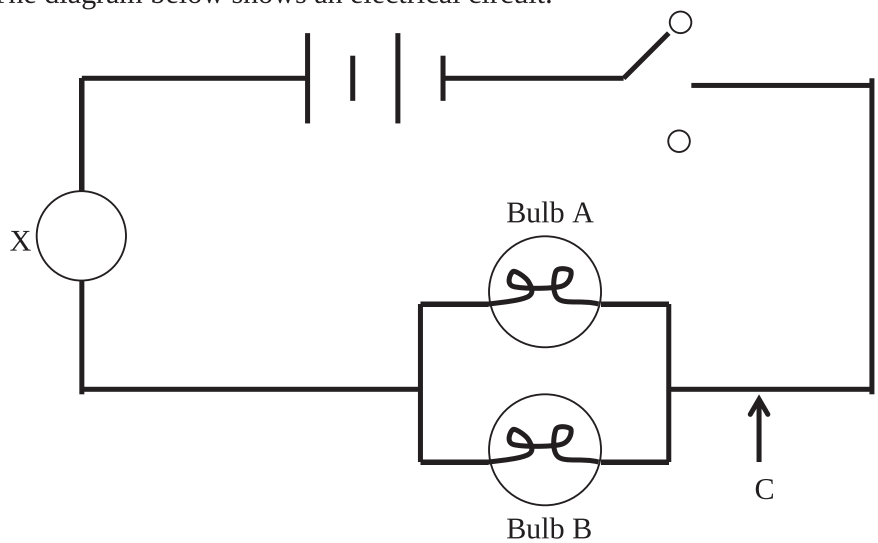
i) What is the function of a gold leaf electroscope? [**2 marks**]

- Answer:
- To test for the presence of charge (1 mark) and to test the type of charge present (1 mark).

- Full Credit: 0/50 (0%)
- Partial Credit: 0/50 (0%)
- Did not attempt: 9/50 (20%)

Question II: Current Electricity

a) The diagram below shows an electrical circuit.




i. Name the instrument that could be installed at ' X ' and state its purpose. [**2 marks**]

- Answer:
  - Name: Ammeter (1 mark)
  - Purpose: Measures amount of current flowing in a circuit (1 mark)

  - Full Credit: 0/50 (0%)
  - Partial Credit:
    - Name: 2/50 (4%)
    - Purpose: 0/50 (0%)
  - Did not attempt: 7/50 (14%)

ii. How will the addition of a third bulb in location ' C ' affect the brightness of Bulb 'A' and Bulb 'B'? [**2 marks**]

- Answer:
  - Bulb 'A': Brightness decreases (1 mark)
  - Bulb 'B': Brightness decreases (1 mark)

  - Full Credit: 3/50 (6%)
  - Partial Credit: 0/50 (0%)
  - Did not attempt: 6/50 (12%)

iii. If one cell is added in series, how will this affect the brightness of the bulbs? [**1 mark**]

- Answer:
  - Brightness will increase (1 mark)

- Full Credit: 2/50 (4%)
- Did not attempt: 4/50 (8%)

iv. What is the disadvantage of connecting streetlights in series? [**2 marks**]

- Answer:
  - If one bulb breaks or burns out, the circuit is disconnected (1 mark) and no light is observed (1 mark).

  - Full Credit: 0/50 (0%)
  - Partial Credit: 0/50 (0%)
  - Did not attempt: 5/50 (10%)

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

- Answer:
  - Connect the street light bulbs in parallel (1 mark)
  - Full Credit: 0/50 (0%)
  - Did not attempt: 12/50 (24%)

Question III: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

a) Give one difference between light waves and sound waves. [**1 mark**]

- Possible Answers:
  - Light waves are transverse in nature, while sound waves are longitudinal (1 mark)
  - Light waves can travel in a vacuum, while sound waves cannot (1 mark)
  - Light waves travel at a speed of 3 x 10^8 m/s, while sound waves travel with a speed of 340 m/s (1 mark)
  - Light waves do not require a medium in order to travel, while sound waves do require a medium in order to travel (1 mark)

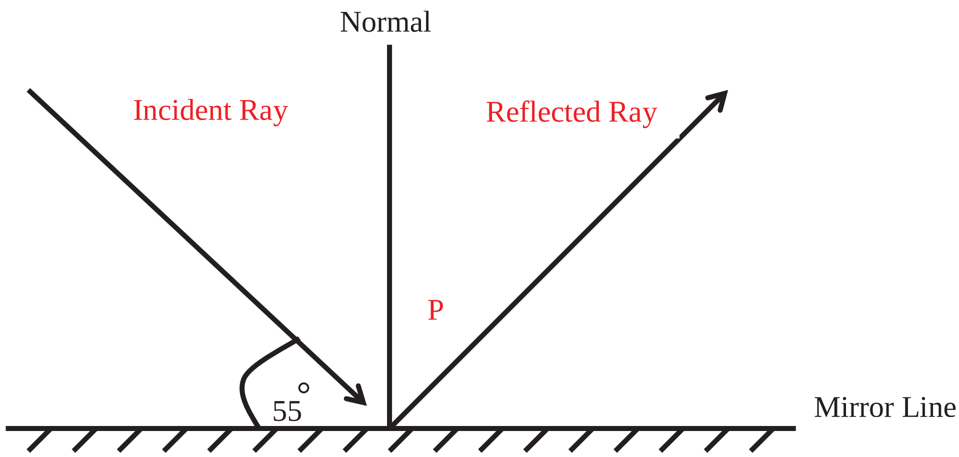
  - Full Credit: 1/50 (2%)
  - Partial Credit: 0/50 (0%)
  - Did not attempt: 4/50 (8%)

b) Name one instrument that functions with the use of light. [**1 mark**]

- Possible Answers:
  - Camera, microscope, binoculars, telescope, etc. (1 mark for 1 right answer)

  - Full Credit: 1/50 (2%)
  - Did not attempt: 5/50 (10%)

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ‘ P ‘ on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

- Answer:
  - P = 90º - 55º (1 mark) = 35º (1 mark)

  - Full Credit: 2/50 (4%)
  - Did not attempt: 17/50 (34%)

  - Labeling:

    - ‘P’:
      - Full Credit: 16/50 (32%)
      - Did not attempt: 5/50 (10%)

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

- Answer:
  - 1 mark for each proper label

    - Incident Ray:
      - Full Credit: 11/50 (22%)
      - Did not attempt: 14/50 (28%)

    - Reflected Ray:

- Full Credit: 19/50 (38%)
- Did not attempt: 12/50 (24%)

*4/50 did not label, but wrote wrong answers under this section.

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? [**3 marks**]

- Possible Answers:
  - Speed = distance traveled / time taken = 3,708 kilometers / 3 hours (1 mark) = 1, 236 (1 mark) km/hr (1 mark)
  - Or 3,708,000 meters / 10,800 seconds (1 mark) = 343.3 (1 mark) m/s (1 mark)

  - Full Credit: 1/50 (2%)
  - Partial Credit:
    - 3,708 km / 3 hrs: 2/50 (10%)
    - 3, 708 km / 3 hrs = 1, 236: 4/50 (8%)
  - Did not attempt: 4/50 (8%)

e) At what speed do electromagnetic waves travel? [**1 mark**]

- Possible Answers:
  - Speed of light (1 mark) or 3 x 10^8 m/s (1 mark)

  - Full Credit: 0/50 (16%)
  - Did not attempt: 8/50 (16%)

f) Give an example of an electromagnetic wave that is not a light wave (not sun rays). [**1 mark**]

- Possible Answer:
  - Any of the following (1 mark): Radio waves, Ultraviolet (UV), Infrared (IR), X-rays, Gamma rays, Microwaves

  - Full Credit: 13/50 (26%)
  - Did not attempt: 5/50 (10%)

Question IV: Chemistry of Water

The diagram below shows the stages in the purification of water at a large scale:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank

↓

Return to river

a) State examples of substances that can be removed in the screening tank. [**1 mark**]

- Possible Answer:
    - Large bits of rubbish like plastics, wood materials, etc. (1 mark)
    - Full Credit: 0/50 (0%)
    - Did not attempt: 4/50 (8%)

b) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

- Answer:
    - Small particles of sand and small stones (1 mark)
    - Full Credit: 3/50 (6%)
    - Did not attempt: 4/50 (8%)

c) What is the purpose of the chlorination tank? [**1 mark**]

- Answer:
    - To kill the germs in water (1 mark)
    - Full Credit: 14/50 (28%)
    - Did not attempt: 2/50 (4%)

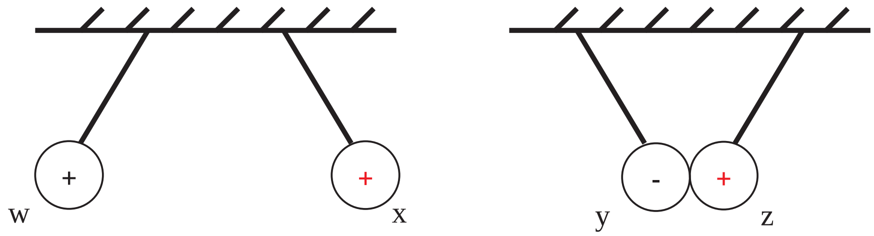
d) Give one difference between hard water and soft water. [**2 marks**]

- Answer:
    - Hard water contains calcium (Ca) (1/2 mark) and magnesium (Mg) (1/2 mark) ions, while soft water does not (1 mark).
    - Full Credit: 1/50 (2%)
    - Partial Credit: 0/50 (0%)
    - Did not attempt: 4/50 (8%)

## <u>Appendix L</u>: Experimental Group A Post-Assessment Results (N=54/55)

<u>Question I</u>: Static Electricity

a) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings. Complete the diagram below, within the empty grey shaded regions, to show the type of charges on balls 'x' and 'z'. [**2 marks**]




- <u>Answer</u>: 'X' is (+)
- <u>Partial Credit</u>: 1/55 (1.8%)

<u>Answer</u>: 'Z' is (+)
<u>Partial Credit</u>: 3/55 (5.45%)

- <u>Full Credit (Both 'X' & 'Z')</u>: 28/55 (50.9%)
- <u>Did not attempt 'X' nor 'Z'</u>: 24/55 (43.6%)

i) What scientific observations are made between: [**2 marks**]

a. 'w' and 'x':

- <u>Answer</u>: Repel each other (1 mark)
  - <u>Full Credit</u>: 37/55 (67%)
  - <u>Did not attempt</u>: 0/55 (0%)

b. 'y' and 'z':

- <u>Answer</u>: Attract each other (1 mark)
  - <u>Full Credit</u>: 39/55 (70.9%)
  - <u>Did not attempt</u>: 0/55 (0%)

ii) Why is the observed behavior of the balls occurring? [**2 marks**]

- <u>Answers</u>:
  - Same charge (+) in 'w' and 'x' (1 mark)
  - Unlike charges (-) and (+) in 'y' and 'z' (1 mark)

Or

  - Like charges repel (1 mark)
  - Unlike charges attract (1 mark)

- <u>Full Credit</u>: 9/55 (16%)
- <u>Partial Credit</u>:
  - Unlike charges (-) (+) 'y' and 'z': 1/55 (1.8%)

        - Like charges repel: 3/55 (5.45%)
        - Unlike charges attract: 2/55 (3.6%)
        - "They are charged": 3/55 (5.45%)
    - Did not attempt: 1/55 (1.8%)

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

Answers:

(1) Charged material is brought close to the cap of the electroscope and charges it by induction either positively or negatively depending on charge in the material (1 mark).

(2) Charge is distributed completely to brass rod and gold leaf. Due to like charges, gold leaf deflects trying to repel from brass rod (1 mark).

(3) To make it neutral, touch the cap with a finger (1 mark).

- Full Credit: 0/55 (0%)
- Partial Credit: 0/55 (0%)
- Did not attempt: 19/55 (34.5%)

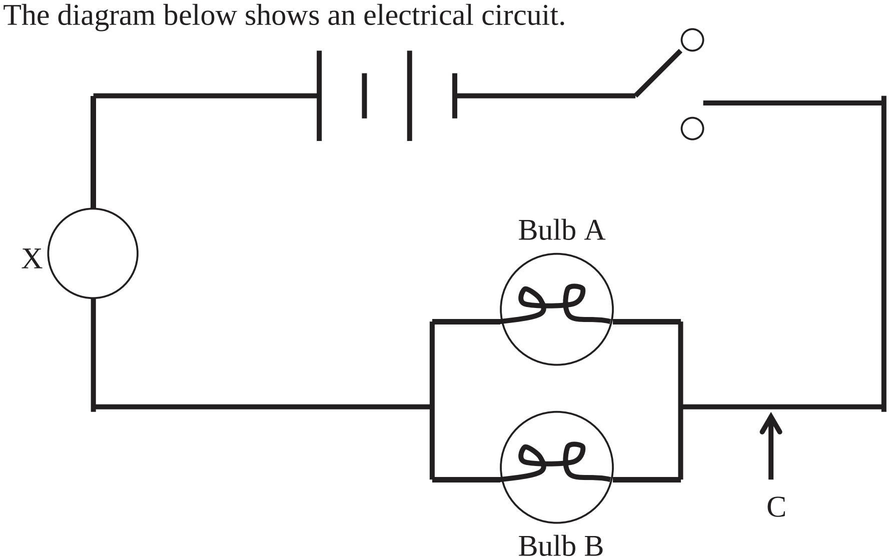
i) What is the function of a gold leaf electroscope? [**2 marks**]

- Answer:
    - To test for the presence of charge (1 mark) and to test the type of charge present (1 mark).

- Full Credit: 0/55 (0%)
- Partial Credit: 0/55 (0%)
- Did not attempt: 11/55 (20%)

Question II: Current Electricity

a) The diagram below shows an electrical circuit.



i. Name the instrument that could be installed within the shaded region labeled ‘ X ‘ and state its purpose. [**2 marks**]

- Answer:
- Name: Ammeter (1 mark)
- Purpose: Measures amount of current flowing in a circuit (1 mark)

- Full Credit: 2/55 (3.6%)
- Partial Credit:
  - Name: 22/55 (40%)
  - Purpose: 7/55 (12.7%)
- Did not attempt: 0/55 (0%)

ii. How will the addition of a third bulb in location ‘ C ‘ on the electrical circuit diagram affect the brightness of Bulb ‘A’ and Bulb ‘B’? [**2 marks**]

- Answer:
- Bulb ‘A’: Brightness decreases (1 mark)
- Bulb ‘B’: Brightness decreases (1 mark)

- Full Credit: 12/55 (21.8%)
- Partial Credit: 3/55 (5.45%)
- Did not attempt: 2/55 (3.6%)

iii. If one cell is added in series, how will this affect the brightness of the bulbs in the circuit? [**1 mark**]

- Answer:
- Brightness will increase (1 mark)

- Full Credit: 16/55 (29%)
- Did not attempt: 1/55 (1.8%)

iv. With regard to electrical circuitry, what is the disadvantage of connecting streetlights in series? [**2 marks**]

- Answer:
- If one bulb breaks or burns out, the circuit is disconnected (1 mark) and no light is observed (1 mark).

- Full Credit: 12/55 (21.8%)
- Partial Credit:
  - One bulb breaks/burns out: 2/55 (3.6%)
- Did not attempt: 0/55 (0%)

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

- Answer:
  - Connect the street light bulbs in parallel (1 mark)

  - Full Credit: 16/55 (29%)
  - Did not attempt: 4/55 (7%)

Question III: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

a) Give one difference between light waves and sound waves. [**1 mark**]

- Possible Answers:
  - Light waves are transverse in nature, while sound waves are longitudinal (1 mark)
  - Light waves can travel in a vacuum, while sound waves cannot (1 mark)
  - Light waves travel at a speed of 3 x 10^8 m/s, while sound waves travel with a speed of 340 m/s (1 mark)
  - Light waves do not require a medium in order to travel, while sound waves do require a medium in order to travel (1 mark)

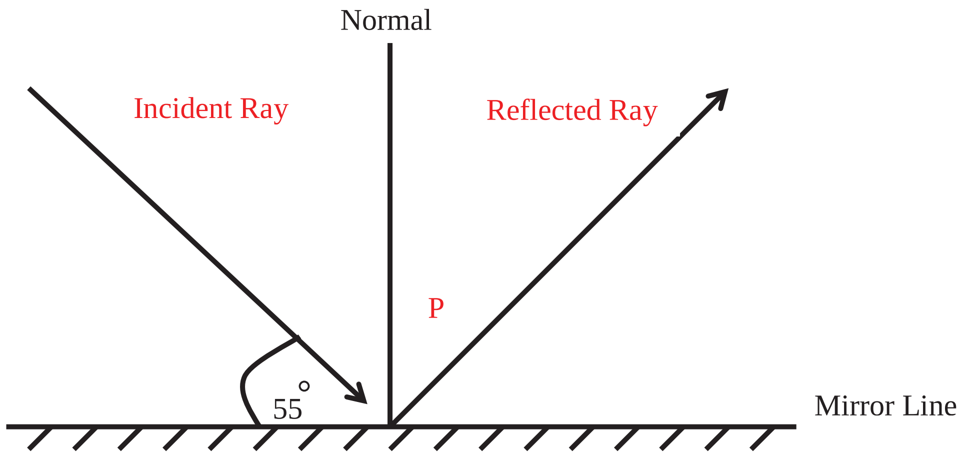
  - Full Credit: 40/55 (72.7%)
  - Partial Credit: 0/55 (0%)
  - Did not attempt: 0/55 (0%)

b) Name one instrument (apparatus) that functions with the use of light. [**1 mark**]

- Possible Answers:
  - Camera, microscope, binoculars, telescope, etc. (1 mark for 1 right answer)

  - Full Credit: 7/55 (12.7%)
  - Did not attempt: 1/55 (1.8%)

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ‘ P ‘ on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

- Answer:
  - P = 90º - 55º (1 mark) = 35º (1 mark)

  - Full Credit: 19/55 (34.5%)
  - Did not attempt: 24/55 (43.6%)

  - Labeling:
    - ‘P’:
      - Full Credit: 13/55 (23.6%)
      - Did not attempt: 4/55 (7%)

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

- Answer:
  - 1 mark for each proper label
    - Incident Ray:
      - Full Credit: 42/55 (76%)
      - Did not attempt: 1/55 (1.8%)
    - Reflected Ray:
      - Full Credit: 43/55 (78%)
      - Did not attempt: 2/55 (3.6%)

*7/55 did not label, but wrote wrong answers under this section.

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? Remember to include the appropriate units. [**3 marks**]

- Possible Answers:
  - Speed = distance traveled / time taken = 3,708 kilometers / 3 hours (1 mark) = 1, 236 (1 mark) km/hr (1 mark)
  - Or 3,708,000 meters / 10,800 seconds (1 mark) = 343.3 (1 mark) m/s (1 mark)

  - Full Credit: 20/55 (36%)
  - Partial Credit:
    - 3,708 km / 3 hrs: 7.5/55 (13.6%)
    - 3, 708 km / 3 hrs = 1, 236: 5/55 (9%)
  - Did not attempt: 1/55 (1.8%)

e) At what speed do electromagnetic waves travel? Remember to include the appropriate units. [**1 mark**]

- Possible Answers:
  - Speed of light (1 mark) or 3 x 10^8 m/s (1 mark)

  - Full Credit: 23/55 (41.8%)
  - Partial Credit (wrong/missing units): 6/55 (10.9%)
  - Did not attempt: 2/55 (3.6%)

f) Provide an example of an electromagnetic wave. You may NOT use “light wave” nor “sun rays” as your example. [**1 mark**]

- Possible Answer:
  - Any of the following (1 mark): Radio waves, Ultraviolet (UV), Infrared (IR), X-rays, Gamma rays, Microwaves

  - Full Credit: 27/55 (49%)
  - Did not attempt: 2/55 (3.6%)

Question IV: Chemistry of Water

The diagram below shows the stages in the purification of water at a large scale:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank

↓

Return to river

a) State examples of substances that can be removed in the screening tank. [**1 mark**]

- Possible Answer:
    - Large bits of rubbish like plastics, wood materials, etc. (1 mark)
    - Full Credit: 20/55 (36%)
    - Did not attempt: 1/55 (1.8%)

b) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

- Answer:
    - Small particles of sand and small stones (1 mark)
    - Full Credit: 17/55 (30.9%)
    - Did not attempt: 1/55 (1.8%)

c) What is the purpose of the chlorination tank? [**1 mark**]

- Answer:
    - To kill the germs in water (1 mark)
    - Full Credit: 32/55 (58%)
    - Did not attempt: 0/55 (0%)

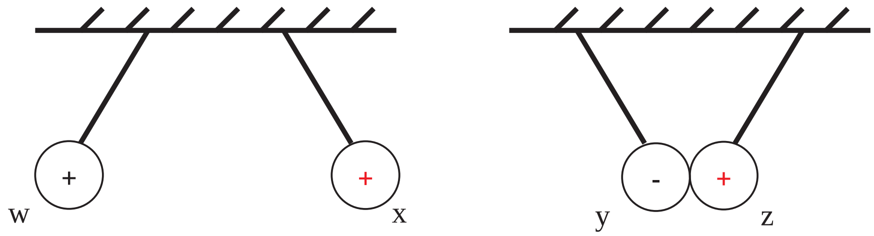
d) Give one difference between hard water and soft water. [**2 marks**]

- Answer:
    - Hard water contains calcium (Ca) (1/2 mark) and magnesium (Mg) (1/2 mark) ions, while soft water does not (1 mark).
    - Full Credit: 17/55 (30.9%)
    - Partial Credit:
        - Hard water (Ca + Mg): 2/55 (3.6%)
        - Soft water: 1/55 (1.8%)
    - Did not attempt: 0/55 (0%)

**Appendix M: Control Group B Post-Assessment Results (N=47/50)**

Question I: Static Electricity

a) The diagram below shows two pairs of charged polythene balls hanging from the ceiling on strings. Complete the diagram below, within the empty grey shaded regions, to show the type of charges on balls 'x' and 'z'. [**2 marks**]




- Answer: 'X' is (+)
- Partial Credit: 0/50 (0%)

- Answer: 'Z' is (+)
- Partial Credit: 7/50 (14%)

- Full Credit (Both 'X' & 'Z'): 20/50 (40%)
- Did not attempt 'X' nor 'Z': 20/50 (40%)

i) What scientific observations are made between: [**2 marks**]

a. 'w' and 'x':

- Answer: Repel each other (1 mark)
  - Full Credit: 40/50 (80%)
  - Did not attempt: 1/50 (2%)

b. 'y' and 'z':

- Answer: Attract each other (1 mark)
  - Full Credit: 38/50 (76%)
  - Did not attempt: 0/50 (0%)

ii) Why is the observed behavior of the balls occurring? [**2 marks**]

- Answers:
  - Same charge (+) in 'w' and 'x' (1 mark)
  - Unlike charges (-) and (+) in 'y' and 'z' (1 mark)

Or

  - Like charges repel (1 mark)
  - Unlike charges attract (1 mark)

- Full Credit: 15/50 (30%)
- Partial Credit:
  - Unlike charges attract: 1/50 (2%)

        - "They are charged": 2/50 (4%)
    - Did not attempt: 7/50 (14%)

b) Describe how a gold leaf electroscope works (operates) [**3 marks**]

Answers:

(1) Charged material is brought close to the cap of the electroscope and charges it by induction either positively or negatively depending on charge in the material (1 mark).

(2) Charge is distributed completely to brass rod and gold leaf. Due to like charges, gold leaf deflects trying to repel from brass rod (1 mark).

(3) To make it neutral, touch the cap with a finger (1 mark).

- Full Credit: 2/50 (4%)
- Partial Credit:
    - (1): 9/50 (18%)
    - (2): 3/50 (6%)
- Did not attempt: 3/50 (6%)

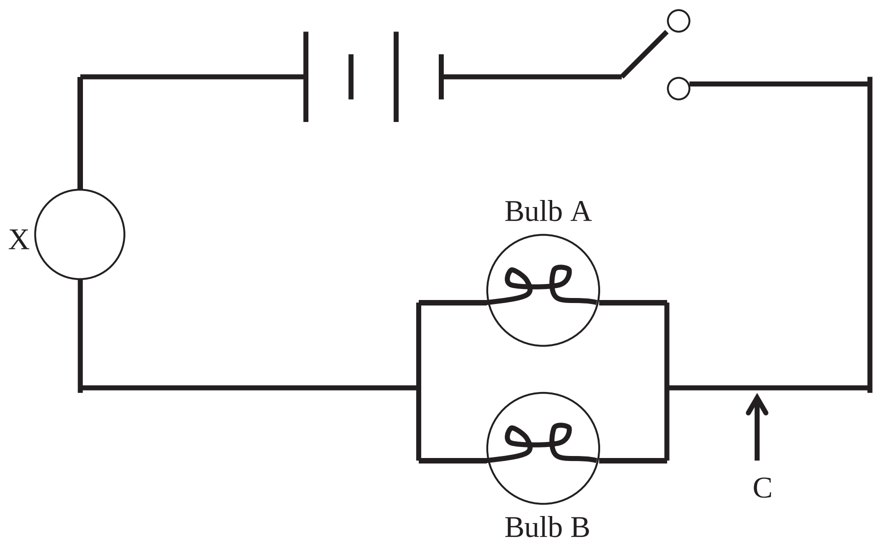
i) What is the function of a gold leaf electroscope? [**2 marks**]

- Answer:
- To test for the presence of charge (1 mark) and to test the type of charge present (1 mark).

- Full Credit: 0/50 (0%)
- Partial Credit:
    - Test presence of charge: 2/50 (40%)
    - Test type of charge: 3/50 (6%)
- Did not attempt: 5/50 (25%)

Question II: Current Electricity

a) The diagram below shows an electrical circuit.




i. Name the instrument that could be installed within the shaded region labeled ‘ X ‘ and state its purpose. [**2 marks**]

- Answer:
  - Name: Ammeter (1 mark)
  - Purpose: Measures amount of current flowing in a circuit (1 mark)

  - Full Credit: 9/50 (18%)
  - Partial Credit:
    - Name: 31/50 (62%)
    - Purpose: 0/50 (0%)
  - Did not attempt: 0/50 (0%)

ii. How will the addition of a third bulb in location ‘ C ‘ on the electrical circuit diagram affect the brightness of Bulb ‘A’ and Bulb ‘B’? [**2 marks**]

- Answer:
  - Bulb ‘A’: Brightness decreases (1 mark)
  - Bulb ‘B’: Brightness decreases (1 mark)

  - Full Credit: 10/50 (20%)
  - Partial Credit:
    - Bulb B: 1/50 (2%)
  - Did not attempt: 6/50 (12%)

iii. If one cell is added in series, how will this affect the brightness of the bulbs in the circuit? [**1 mark**]

- Answer:
    - Brightness will increase (1 mark)
    - Full Credit: 19/50 (38%)
    - Did not attempt: 1/50 (1.8%)

iv. With regard to electrical circuitry, what is the disadvantage of connecting streetlights in series? [**2 marks**]

- Answer:
    - If one bulb breaks or burns out, the circuit is disconnected (1 mark) and no light is observed (1 mark).

    - Full Credit: 0/50 (0%)
    - Partial Credit: 0/50 (0%)
    - Did not attempt: 5/50 (10%)

v. Suggest a way of avoiding the disadvantage mentioned in the previous question. [**1 mark**]

- Answer:
    - Connect the street light bulbs in parallel (1 mark)

    - Full Credit: 3/50 (28%)
    - Did not attempt: 14/50 (7%)

Question III: Electromagnetic Waves

*Light is a form of energy that is transformed as electromagnetic waves.*

a) Give one difference between light waves and sound waves. [**1 mark**]

- Possible Answers:
    - Light waves are transverse in nature, while sound waves are longitudinal (1 mark)
    - Light waves can travel in a vacuum, while sound waves cannot (1 mark)
    - Light waves travel at a speed of 3 x 10^8 m/s, while sound waves travel with a speed of 340 m/s (1 mark)
    - Light waves do not require a medium in order to travel, while sound waves do require a medium in order to travel (1 mark)

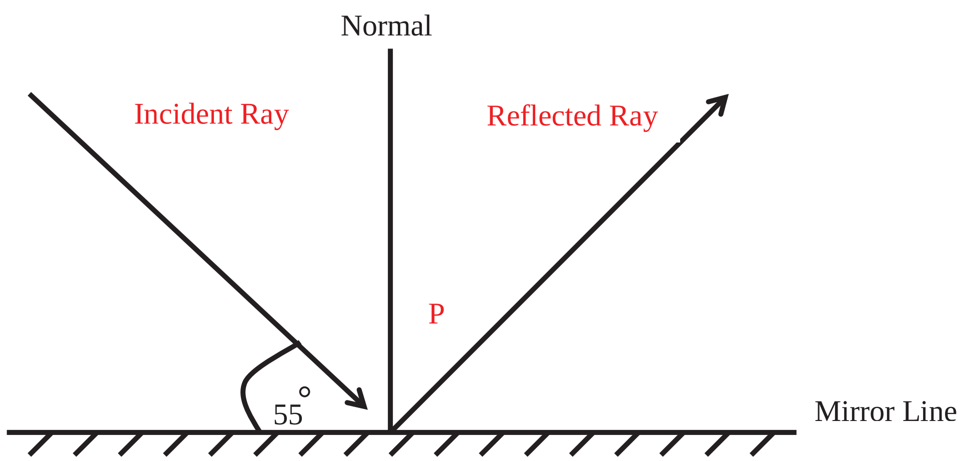
    - Full Credit: 14/50 (28%)
    - Partial Credit: 0/50 (0%)
    - Did not attempt: 1/50 (2%)

b) Name one instrument (apparatus) that functions with the use of light. [**1 mark**]

- Possible Answers:
  - Camera, microscope, binoculars, telescope, etc. (1 mark for 1 right answer)

  - Full Credit: 1/50 (2%)
  - Did not attempt: 4/50 (8%)

c) When a ray of light is incident to a plane mirror, it is reflected as shown on the diagram below:




i. Mark with a letter ‘ P ‘ on the diagram above the angle of reflection and find the value of the angle of reflection. [**2 marks**]

- Answer:
  - P = 90º - 55º (1 mark) = 35º (1 mark)

  - Full Credit: 12/50 (24%)
  - Did not attempt: 19/50 (38%)

  - Labeling:

    - ‘P’:
      - Full Credit: 31/50 (62%)
      - Did not attempt: 2/50 (4%)

ii. Label on the diagram above the incident ray and the reflected ray. [**2 marks**]

- Answer:
  - 1 mark for each proper label

    - Incident Ray:

            - Full Credit: 35/50 (70%)
            - Did not attempt: 1/50 (1.8%)

        - Reflected Ray:
            - Full Credit: 40/50 (2%)
            - Did not attempt: 1/50 (1.8%)

*2/50 did not label, but wrote wrong answers under this section.

d) If sound travels 3, 708 km in water every three (3) hours, what will be the speed it is traveling at? Remember to include the appropriate units. [**3 marks**]

- Possible Answers:
    - Speed = distance traveled / time taken = 3,708 kilometers / 3 hours (1 mark) = 1, 236 (1 mark) km/hr (1 mark)
    - Or 3,708,000 meters / 10,800 seconds (1 mark) = 343.3 (1 mark) m/s (1 mark)

    - Full Credit: 1/50 (1.8%)
    - Partial Credit:
        - 3,708 km / 3 hrs: 8/50 (16%)
        - 3, 708 km / 3 hrs = 1, 236 (wrong/missing units): 14/50 (28%)
        - 3, 708 km / 3 hrs = 1, 236 (incomplete units): 3/50 (6%)
    - Did not attempt: 0/50 (0%)

e) At what speed do electromagnetic waves travel? Remember to include the appropriate units. [**1 mark**]

- Possible Answers:
    - Speed of light (1 mark) or 3 x 10^8 m/s (1 mark)

    - Full Credit: 5/50 (10%)
    - Partial Credit (wrong/missing units): 4/50 (8%)
    - Did not attempt: 5/50 (10%)

f) Provide an example of an electromagnetic wave. You may NOT use "light wave" nor "sun rays" as your example. [**1 mark**]

- Possible Answer:
    - Any of the following (1 mark): Radio waves, Ultraviolet (UV), Infrared (IR), X-rays, Gamma rays, Microwaves

    - Full Credit: 26/50 (52%)
    - Did not attempt: 4/50 (8%)

Question IV: Chemistry of Water

The diagram below shows the stages in the purification of water at a large scale:

Sewage Water → Screening Tank → Sedimentation (settlement) Tank → Gravel Filter → Chlorination Tank ↓ Return to river

a) State examples of substances that can be removed in the screening tank. [**1 mark**]

- Possible Answer:
  - Large bits of rubbish like plastics, wood materials, etc. (1 mark)

  - Full Credit: 11/50 (22%)
  - Did not attempt: 0/50 (0%)

b) Name one substance that sinks to the bottom of the sedimentation tank. [**1 mark**]

- Answer:
  - Small particles of sand and small stones (1 mark)

  - Full Credit: 18/50 (36%)
  - Did not attempt: 1/50 (1.8%)

c) What is the purpose of the chlorination tank? [**1 mark**]

- Answer:
  - To kill the germs in water (1 mark)

  - Full Credit: 31/50 (62%)
  - Did not attempt: 1/50 (1.8%)

d) Give one difference between hard water and soft water. [**2 marks**]

- Answer:
  - Hard water contains calcium (Ca) (1/2 mark) and magnesium (Mg) (1/2 mark) ions, while soft water does not (1 mark).

  - Full Credit: 2/50 (4%)
  - Partial Credit: 0/50 (0%)
  - Did not attempt: 4/50 (8%)