

UTILIZATION OF LEARNING ACTIVITY PACKAGE IN THE CLASSROOM: IMPACT ON SENIOR SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN ORGANIC CHEMISTRY

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ABSTRACT

This study examined the impact of the utilization of Learning Activity Package (LAP) in the classroom and its effect on urban and rural students' academic achievement in organic chemistry. Two research questions and three hypotheses guided the study. The study adopted quasi-experimental design. The population comprised 4,164 senior secondary two (SS2) chemistry students of Afikpo Education zone of Ebonyi State, Nigeria. The sample was 235 students drawn from 4 schools by balloting. The experimental groups were taught with LAP while the control groups were taught with Lecture. The instruments used were Learning Activity Package Manual (LAPM) and Chemistry Achievement Test on Organic Chemistry (CATOC) which were validated by three experts. Reliability index of .82 was obtained for the CATOC using Kuder Richardson's formula 20 which showed that it was reliable. The data collected were analyzed using the mean, standard deviation and analysis of covariance (ANCOVA). Results of data analysis revealed among others that, utilization of Learning Activity Package in the classroom had greater impact on the students' academic achievement in organic chemistry than the Lecture method. Furthermore, there was no significant difference in the academic achievement of urban and rural students in chemistry when taught with LAP and Lecture method. The researcher recommended among others things that chemistry teachers should be encouraged to utilize the LAP in their classrooms in order to encourage students' active engagement in the lesson for enhanced academic achievement. [*African Journal of Chemical Education—AJCE 8(2), July 2018*]

INTRODUCTION

The teacher's role in every teaching and learning process cannot be overemphasised. This is because the pace set by the teacher in the classroom is what determines whether students can learn or not. Moreover, the teaching strategies/methods adopted by the teacher will either enhance or hamper the students' academic achievement, especially in chemistry. According to [1], methodology is the ways and means by which the teacher presents his materials to the students and engages them in task at hand. Chemistry being a subject most students are perhaps afraid of requires the teachers to use appropriate teaching methods that will arouse the students' interest and encourage them to develop positive attitude for effective learning outcome.

Generally, science educators have been canvassing for science teachers at all levels to focus on the utilisation of teaching strategies that can enhance students' conceptual understanding, give them higher levels of performance in scientific thinking, reasoning and problem solving. It is important to point out that chemistry play important roles in the scientific and technological development of nations [2].

Unfortunately, research studies have shown that Nigerian secondary school students' performance in the subject chemistry in both internal and external examinations have consistently been poor [3,4,5]. Meanwhile, researchers have discovered that the causes of the persistent poor academic performance have been attributed to; ineffective teaching methods/strategies adopted by chemistry teachers [6,7]; apparent difficulty associated to chemistry by students [8]; among others reasons.

Based on these facts, the researcher is of the view that when chemistry teachers utilises appropriate teaching strategies, which are student-centred and activity-oriented, the chemistry concepts would be easily understood by the students. This can lead to improved students' academic

performance in the subject. There are many student-centred and activity-oriented teaching strategies, but this study focussed on the Learning Activity Package (LAP). Available empirical evidence as documented in the literature review section of this study has shown that the learning activity package (LAP) enhances students' academic achievement more than the conventional teaching approaches. This present study is poised to investigate the effectiveness or otherwise of LAP in enhancing students' academic achievement in organic chemistry.

LITERATURE REVIEW

Theoretical framework

The theoretical foundations of LAP grew out of the work of psychologist, Jean Piaget, who in 1926 advanced a theory to explain the development of cognitive abilities in children [9]. Piaget proposed that cognitive development proceeds through an orderly sequence of stages. Piaget's theory is not only concerned with a child's mental developmental stages but also recognises the differences in individuals of the same age groups or mental state. He stressed further that recognising the differences that exists among learners' mental readiness, interest and needs, will enhance the setting of learners on a learning pedestal appropriate to each stage of mental development. The learners will gradually work at their own pace and accomplish the terminal task, irrespective of their speed or educational linkage.

Therefore, Piaget's idea tallies with learning activity package instructional strategy, which caters for learners', interests, needs and aspirations. According to Piaget, mental activity of the child is organised into structures. Various mental activities are related to each other and grouped together in clusters, which are known as 'schemas' or patterns of behaviour. According to

Woolfolk and Nicolich in [10], the schema is the primary unit of cognitive organisation in the Piagetian system. This means that it is the basic building block of thinking.

Piaget believed that mental activity which is involved in cognitive organisation is a process of adaptation which is divided into two opposing but inseparable processes of assimilation and accommodation. In assimilation, a child fits his new experience into pre-existing mental structures. He interprets his new experience with respect to his old experience. Accommodation involves a change of mental structure due to the influence of the environment which means the modification of self to fit the new materials. The Piagetian theory thus places the child as the principal agent in the teaching/learning situation.

This being the case, the teacher's job is to provide the individual with situations that encourage experimentation and manipulation of objects and symbols. More so, the theory has direct implication for the use of Learning Activity Package in science teaching, especially in Chemistry. This is based on the fact that the LAP encourages active interaction of the child with his environment because it is student-centred and activity-based. The teacher acting as a facilitator of learning guides the students through series of activities and problems, which enhances achievement. In addition, learning materials are broken into small steps which are sequentially arranged from known to unknown and in an increasing order of difficulty in LAP.

From the foregoing, Learning Activity Package accommodates both fast and slow learners in the classroom. It should therefore be used to teach the concepts in organic chemistry which will help to concretize the apparent abstractness of the concepts and will also help the students to learn. [11] opined that it is essentially important for the students to participate actively rather than merely listen during class lessons.

The Learning Activity Package (LAP)

According to Cardarelli in [10], Learning Activity Package (LAP) is a student-centered and activity-based teaching strategy, where the teacher acts as facilitator of learning, guiding the students through series of activities and problems that may lead to enhanced students' academic achievement. Contributing, [12] stated that Learning Activity Package is a program of study in printed form which covers a particular aspect of a subject that follows a logical sequence of instructional objectives and activities for implementing the objectives. The student proceeds through the objectives and activities in the LAP at his/her own pace. Continuing, Duke maintained that in LAP, the learning materials are broken down and arranged sequentially into small steps, ranging from the known to the unknown and in an increasing order of difficulty. This implies from the foregoing that in the LAP instructions are individualised.

Furthermore, Learning Activity Package offers a very practical and successful method for individualizing instruction. For instance, it gives students the opportunity to engage actively in the teaching and learning process by engaging in hands-on activities. Unlike the traditional classroom where the teacher talks much and the students go through their textbooks and workbooks, page by page, lock stepped together. Furthermore, in the traditional/conventional method, there is little or no provision for meeting differences in individual learning styles or differences in individual learning rates. But, the LAP provides the students the opportunity to grow in self-discipline, self-motivation and also presents occasions for genuine interaction between the teacher and students, which is lacking in the traditional method of teaching [13].

Contributing, [14] emphasised that the Learning Activity Package is one of the approaches to individualised instruction. There are many other approaches to individualised instructions such as; programmed instruction, computer assisted instruction, independent study, among others.

Some of these approaches have been investigated and found to be effective in enhancing students' academic achievement but their applications in the teaching and learning process are hindered by several factors in Nigerian schools [15,10]. Hence the need for the use of Learning Activity Package (LAP) which can be readily prepared/constructed by the chemistry teachers.

Influence of School Location on Students' Academic Achievement in Chemistry

For the purpose of this study, the urban schools are those schools located within the Local Government Headquarters, while the rural schools are those located outside the Local Government headquarters. School location refers to the particular place, in relation to other areas/places in the physical environment where a particular school is sited. It could be urban or rural. Basically, environment may have direct or indirect influence on human abilities; it could enhance or inhibit ability to learn [16]. [17] discovered a lot of problems in the teaching and learning of science and technology in the rural environments, such as; high student-teacher ratio, teaching method factor, quality and quantity of science teachers, problem of improvisation, lack of fund for science education and inadequate supervision of rural secondary schools. It is not known whether these factors can contribute to students' poor academic performance in the rural schools. This study is poised to find out.

From the foregoing, school location could be a factor that can influence students' achievement in chemistry. [18], found that school location influences student's academic achievement in chemistry. Specifically, [19,20], revealed that urban students had higher academic achievement than their rural counterparts in chemistry. In addition, [21] found that chemistry students in urban schools performed better than their rural counterparts. On the other hand, [22,16] reported that rural students performed better than their urban counterparts in chemistry. However, [23,24] found no significant influence of school location on students' academic achievement in

chemistry. It can be established from the above that the influence of school location on students' academic achievement remains inconclusive and therefore calls for further studies, thereby justifying this present study.

Related Empirical Studies

Few researchers have examined the effect of Learning Activity Package on students' academic achievement. A study on the effect of Learning Activity Package (LAP) on male and female students' academic achievement in secondary school Biology was carried out by [10] in Enugu State. The study specifically determined the mean achievement scores of male and female students in Biology when taught Unit of life with Learning Activity Package and lecture method. The study found significant difference in the academic achievement of students taught Biology using LAP and Lecture methods; those students taught with LAP had higher academic achievement than those taught with Lecture method. The study concluded that students' academic achievement will be greatly enhanced when innovative strategies like Learning Activity Package are employed in the teaching and learning of science subjects. Neboh's study was on the effects of LAP and Lecture methods on students' achievement in Biology but did not consider the effect of location. Moreover, the study was conducted in Enugu State. This present study was conducted in Chemistry and considered location as a variable.

In another study on the effectiveness of LAP and Lecture instructional methods of teaching Biology at the senior secondary level of education in Zaria, Kaduna State, Nigeria [15]. The result showed that LAP enhanced the students' achievement in Biology irrespective of their previous academic standings. The study was only confined to two schools in Zaria Township and no attempt was made by the researcher to control some extraneous variables that might have constituted a threat to the validity of the study such as irregular participation of the subjects and inter-group

communication during the experiment. Furthermore, school location was not considered a variable in the study. But, this present study considered school location as variable. Extraneous variables such as teacher effect, subject interaction, Hawthorne effect etc. were controlled. Above all, this study focused on Chemistry and was conducted in Ebonyi State.

More so, studies conducted by [16] on influence of gender and location on students' achievement in chemical bonding in secondary schools in Nsukka education zone of Enugu State Nigeria, found that school location has significant influence on students' achievement in chemistry. The study showed that the mean academic achievement score of rural students in chemical bonding was higher than that of their urban counterparts.

Meanwhile, most of the related empirical studies already carried out on the LAP were conducted in Biology. It therefore becomes necessary to conduct this present study in Chemistry. To find out if similar results obtained in Biology could also be obtained in Chemistry.

STATEMENT OF THE PROBLEM

Research studies have shown that Nigerian candidates in the West African School Certificate Examinations have been recording consistent poor performance in chemistry [25,26,4,5]. In a bid to identify the possible causes of this persistent poor academic performance, researchers have identified the use of ineffective teaching methods by the teachers and the apparent difficulty associated to chemistry by students, among others reasons that could be responsible. Moreover, students find organic chemistry difficult to understand, this might be as a result of the apparent abstract nature of the concepts and the pedagogic approaches adopted by teachers in presenting it to the students [27]. Meanwhile, research studies have acknowledged the effectiveness of the learning activity package (LAP) in enhancing greater students' academic

performance in some subject areas as presented in the literature. This present study therefore examined the learning activity package instructional strategy, to find out whether it can as well be effective in enhancing students' academic performance in organic chemistry.

PURPOSE OF THE STUDY, RESEARCH QUESTIONS AND HYPOTHESES

The main purpose of this study is to examine the utilisation of Learning Activity Package (LAP) in the classroom and its impact on students' academic achievement in organic chemistry. Specifically, this study sought to determine the;

1. Impact of Learning Activity Package on students' academic achievement in organic chemistry;
2. Influence of teaching methods (LAP and Lecture) on urban and rural students' academic achievement in organic chemistry.
3. Interaction effect of method and location on students' academic achievement in organic chemistry.

In order to achieve the purpose of this research work, the study sought answers to the following questions:

1. Is there any significant difference in the academic achievement of students taught organic chemistry with LAP and those taught with conventional (Lecture) method?
2. Does significant difference exist in the academic achievement of urban and rural students taught organic chemistry with LAP and conventional (Lecture) method?

The following null hypotheses tested at 5% level of significance guided the study;

H01. There is no significant difference in the academic achievement of students taught organic chemistry with LAP and those taught with conventional (Lecture) method.

H02. Significant difference does not exist in the academic achievement of urban and rural students taught organic chemistry with LAP and conventional (Lecture) method.

H03. The interaction effect of method and location on students' academic achievement in organic chemistry is not significant.

METHODOLOGY

Research Design

The researcher adopted quasi-experimental design for the study. The pre-test, post-test, non-equivalent, control group design was the specific quasi-experimental design used. Quasi-experiments are experiments used when a researcher cannot use random assignment of subjects or groups [28]. The design was chosen because the subjects for the study could not be manipulated or randomised. Intact classes were used and the classes were assigned to experimental and control groups.

Area of the Study

The study was carried out in Afikpo Education zone which is one of the three educational zones of Ebonyi State, Nigeria. The zone is made up of five local government areas with 35 senior secondary schools that offer chemistry at WAEC level. The names of the local governments with the numbers of schools are as follows; Afikpo North has 10 schools, Afikpo South has 8 schools, Ohaozara has 6 schools, Onicha has 8 schools while Ivo has 3 schools. The zone was selected for this study because the schools are homogenous and are under the same education authority. Secondly, for ease of access and convenience for effective management of the available financial resources meant for the study. This is because the researcher had to monitor the activities of the

teachers to ensure their agreement with the stipulated plans of the study by visiting the sampled schools regularly during the period of the study.

Population, Sample and Sampling Techniques

The population for the study was 4,164 Senior Secondary 2 chemistry students in Afikpo Education zone in the 2015/2016 academic session. This grade of students was chosen because organic chemistry is contained in the SS2 section of the chemistry curriculum in use in Nigerian schools.

Using simple random sampling (balloting) technique, a sample of 235 SSII chemistry students (125 urban and 110 rural) was drawn from 4 co-educational (2 urban and 2 rural) secondary schools in Afikpo Education zone of Ebonyi State, Nigeria. Two intact classes in each of the schools were randomly assigned to experimental groups (120 students) and control groups (115 students). The sampled schools were selected on the bases that there were co-educational and chemistry had been taught in the schools for over ten years. Also, the number of students in each of the classes was not more than 40.

Instruments for Data Collection, Validation and Reliability

Two major instruments were used for the study, they are; Learning Activity Package Manual (LAPM) and Chemistry Achievement Test on Organic Chemistry (CATOC). The LAPM was adapted from the works of [29] who constructed the Learning Activity Package that comprised seven basic components/parts; the pre-test, performance objectives, concept, learning activities, self-test/evaluation, mastery/post-test, and enrichment opportunities. The LAP manual covered the following contents in organic chemistry as contained in SS2 chemistry curriculum; Structure and valency of carbon; Hydrocarbon; Homologous series; Saturated and unsaturated hydrocarbons; Isomerism; and Aromatic hydrocarbons.

The CATOC comprised 25 multiple-choice test items drawn from the various organic chemistry units outlined above. The researcher developed the test items using a test blue-print/table of specification to determine number of test items for each topic along three categories of cognitive objective, namely: knowledge (remembering), comprehension (understanding) and application (thinking). Each test item had four response options A - D with only one option as the correct answer while others were distracters.

Both the LAPM and the CATOC were content and face validated by two experts in chemistry education and one expert in measurement and evaluation from the Faculty of Education of Ebonyi State University. The instruments were revised based on the experts' suggestions. Specifically, the test items of the CATOC were adjusted and evaluated according to the experts' comments before it was used as pre-test and post-test.

The reliability of the CATOC was determined by pilot-testing the testing it on 40 SS2 chemistry students of Government Technical College, Abakaliki who were not part of the study subjects. Using Kuder-Richardson formula 20 (KR-20) reliability index of .82 was obtained, which confirmed the instrument as being reliable. This was in line with the established standard that any instrument with reliability index of .7 and above is adjudged reliable [30].

Procedure for Data Collection and Method of Data Analysis

The researcher organised a 5-day seminar/workshop for the regular chemistry teachers of the sampled schools where they were trained on the use of the learning activity package (LAP) in chemistry lesson delivery. During the seminar/workshop, copies of the LAPM which was derived from the organic chemistry curriculum contents of the students were given to the teachers. They were drilled thoroughly by the researcher on the use of the Learning Activity Package in chemistry instructions. The researcher observed as the teachers utilised the LAPM in delivering the lesson

and made corrections where necessary. The teachers were instructed to teach the control group using the conventional (lecture) method the way they have been using it in their classrooms. After the seminar, the teachers commenced the exercise in their respective schools. On the first day of commencement of the exercise, each of the teachers administered the CATOC to the students, as pre-test for the duration of 50 minutes and recorded their scores.

Experimental group

The treatment was teaching the students using the Learning Activity Package for the duration of four weeks. Four experimental lessons were carried out on different topics in organic chemistry.

Procedure: The teacher distributed the LAP manual to the students. Each student was to carry out the required activities as contained in the manual. The Pre-test was to test the student's knowledge of the subject matter, note that the pre-test in the LAP differed from the pre-test which was initially administered to the students before the commencement of the experiments. After the pre-test, the performance objectives were identified. The Concept; defined, explained and illustrated the contents of the topic. The students thereafter carried out the learning activities expected of them on individual bases. When through with the learning activities, each student engaged in self-test/evaluation to test their understanding of the material studied. They proceed to mastery/post-test, if they answered the self-test correctly or to enrichment opportunities which entailed studying more materials until they can answer the self-test correctly. Each student progressed on the manual at their own pace. The teacher uses the mastery test to assess each student's progress to know whether a student can proceed to the next lesson or needed to be drilled more on the particular lesson/topic. At the end of the four weeks' treatment, a post-test (which was a reshuffled version of the pre-test) was administered to the students and the scores recorded.

Control

The pre-test was first administered to the students. The teacher thereafter taught them four lessons in organic chemistry using the conventional (lecture) method. The lessons were delivered using the chalk and chalkboard. The students were given assignments which the teacher marked and went through the corrections with them. At the end of the four weeks' duration, the post-test was administered to the students and the scores recorded.

The pre-test and post-test scores of the experimental and control groups were used for data analysis. The research questions were answered by using the results to calculate the mean achievement scores and standard deviations of the groups, whereas the hypotheses were tested with Analysis of Covariance (ANCOVA) using the pre-test scores as covariates.

RESULTS AND DISCUSSIONS

Research question 1: Is there any difference in the academic achievement of students taught organic chemistry with LAP and those taught with conventional (Lecture) method?

Table 1: Mean Achievement Scores and Standard deviations of Students

Experimental Conditions	Teaching Method	Test Type	No. Of Subjects (N)	Mean (X)	Standard Deviation (SD)	Gain Score
Experimental	LAP	Pre-test	120	7.60	3.15	19.55
		Post-test		27.15	6.13	
Control	Lecture	Pre-test	115	7.45	3.40	10.70
		Post-test		18.15	5.80	
Total			235			

As shown in Table 1, the mean scores of the students taught organic chemistry with LAP and Lecture method are 7.60 and 7.45 respectively in the pre-tests. The difference in the pre-test mean scores of the two groups is .15. This shows that the two groups were similar at the beginning of the experiment. The Table 1 further shows that the mean achievement score of the students

taught organic chemistry with LAP in the post-test is 27.15 with standard deviation of 6.13 and mean achievement gain score of 19.55. On the other hand, the mean achievement score of those taught with the Lecture method in the post-test is 18.15 with standard deviation of 5.80 and mean achievement gain score of 10.70. The difference in the mean achievement gain scores of the two groups is 8.85. Therefore, difference exists in the academic achievement of students taught with LAP and those taught with Lecture method. Those students taught with LAP had higher academic achievement than their counterparts who were taught with Lecture method. Moreover, the standard deviations of the two groups in the post-tests are 6.13 and 5.80 for the LAP and Lecture method respectively. This is an indication that the individual scores of the students were clustered around the mean in the Lecture method more than in the LAP.

However, Table 1 did not show whether the observed difference in the mean achievement score of the two groups in the post-test is significant. Therefore, the result was further subjected to inferential testing as shown in hypothesis 1, in order to ascertain whether the observed difference is significance or not.

Hypothesis 1: There is no significant difference in the academic achievement of students taught organic chemistry with LAP and those taught with conventional (Lecture) method.

Table 2: Analysis of Covariance (ANCOVA) of Students' Overall Achievement Scores by Teaching Method and Location

Source of Variation	Type III Sum of Squares	Df	Mean Square	F-cal	P-value	Decision
Corrected Model	658.942	2	329.471	3.675	.013	S
Intercept	126530.064	1	126530.064	2117.296	.000	S
Method	658.942	2	329.471	3.675	.013	S
Location	198.450	1	198.450	3.321	.070	NS
Method X Location	48.606	2	24.303	.814	.636	NS
Error	13804.607	231	59.760			
Total	142066.000	235				
Corrected Total	14463.549	234				

S = Significant ($P < .05$); NS = Not Significant ($P > .05$)

Table 2 shows that there is a significant difference in the academic achievement of students taught organic chemistry with LAP and those taught with conventional (lecture) method. This is because from the table, the probability value of .013 obtained is lower than the level of .05 at which it was tested. Therefore, the null hypothesis (Ho1) of no significant difference in the students' academic achievement is rejected at .05 level of confidence. This means that the earlier observed difference in the overall mean achievement scores of students taught organic chemistry with LAP and those taught with conventional (lecture) method, as shown in Table 1 is significant.

Furthermore, the academic achievement of the students taught with LAP having been found to be higher than those taught with the conventional (lecture) method signifies that LAP had greater impact on the students' academic achievement in the organic chemistry than the lecture method.

Research question 2: Does significant difference exist in the academic achievement of urban and rural students taught organic chemistry with LAP and Lecture method?

Table 3: Mean Achievement Scores and Standard Deviations of Urban and Rural Students

Experimental Conditions	Teaching Methods	School location	Test type	No. of subjects (N)	Mean (X)	Standard deviation (SD)	Gain Score
Experimental	LAP	Urban	Pre-test	64	7.34	3.07	19.34
			Post-test		26.68	6.66	
	Rural	Pre-test	61	6.75	2.57		
		Post-test		24.28	8.53		
Control	Lecture	Urban	Pre-test	56	7.40	2.25	11.37
			Post-test		18.77	6.05	
	Rural	Pre-test	54	6.58	2.48		
		Post-test		16.72	4.19		
Total				235			

Table 3 shows the mean pre-test and post-test scores of urban and rural students taught organic chemistry with LAP and Lecture method. The Table 3 shows that the urban students taught with LAP has mean achievement gain score of 19.34 while their counterparts in the rural schools

has mean achievement gain score of 17.53. The mean achievement gain score of the urban students taught with LAP (experimental) is 1.81 higher than that of their rural counterparts.

Furthermore, Table 3 shows that the mean achievement gain score of the urban students in the control group taught with Lecture method is 11.37 while that of their rural counterparts is 10.14. From this result, the mean achievement gain score of the urban students taught with Lecture method (control) is 1.23 higher than that of their rural counterparts. These results shows that differences exist in the mean achievement scores of urban and rural students taught with LAP and Lecture method. However, it was not shown on the Table whether the observed differences in the urban and rural students' mean achievement scores in the LAP and Lecture method are significant. Therefore, the result was further subjected to inferential testing in order to ascertain whether the observed difference is significance, as shown in hypothesis 2.

Hypothesis 2: Significant difference does not exist in the academic achievement of urban and rural students taught organic chemistry with LAP and Lecture method.

From Table 2, non-significant difference was found in the Post-achievement test scores of the urban and rural students. This is because the probability value of .070 obtained is greater than the level of .05 at which it was tested. With this result, Ho2 was retained because the observed difference in the academic achievement of urban and rural students in organic chemistry is not significant. Thus, the efficacy of the methods in enhancing students' achievement in chemistry according to this finding was not influenced by school location.

Hypothesis 3: The interaction effect of method and location on students' academic achievement in organic chemistry is not significant.

In Table 2, the F-value for the interaction effect of method and location on students' academic achievement in organic chemistry is .814 with P-value of .636 which is greater than .05

set for the study. With this result, H_03 was retained. Hence, the two-way interaction of method and location has no significant effect on students' academic achievement in organic chemistry. Meanwhile, since method is significant while the interaction with location is not, it therefore shows that method does not depend on school location to be effective.

SUMMARY OF MAJOR FINDINGS

1. There is a significant difference in the academic achievement of students taught organic chemistry with learning activity package and those taught with conventional (lecture) method.
2. The Learning Activity Package enhances students' academic achievement in organic chemistry more than the conventional (lecture) method. This implies that LAP has more impact on students' academic achievement than the conventional (lecture) method.
3. There is no significant difference in the academic achievement of urban and rural students in organic chemistry.
4. The two-way interaction effect of method and location on students' academic achievement in organic chemistry is not significant.

DISCUSSION

The findings of this study have shown that students taught with Learning Activity Package (LAP) had higher academic achievement than those taught with conventional (lecture) method. The LAP therefore has greater impact on students' academic achievement in organic chemistry than the Lecture method. This finding agrees with the findings of previous researchers, [10,15] that Learning Activity Package (LAP) is more effective than the Lecture method in enhancing students' academic achievement in science. Meanwhile, the relative effectiveness of LAP over the

Lecture method in enhancing students' academic achievement could be attributed to the fact that LAP is a student-centred and activity-based method of instruction which provided the students the opportunity to have direct contact with the materials of study. Given the different approaches by which the two methods (LAP and Lecture) were utilised, it is not surprising that the LAP had greater impact on students' academic achievement than the lecture method.

This study further found no statistically significant difference in the academic achievement of urban and rural students in organic chemistry. Although the mean achievement scores of urban students were higher than that of their rural counterparts in the LAP and Lecture method, the differences were not statistically significant. These shows that the efficacy of the teaching methods in enhancing students' achievement was not influenced by school location. This finding agrees with the findings of [23,24] that there is no significant influence of school location on students' academic achievement. The finding also agrees with [3] that there is no significant difference in the academic achievement of urban and rural students in physics. However, the finding of this study disagrees with the findings of [21,31] that chemistry and mathematics students in urban schools performed better than their rural counterparts. The finding also disagrees with [16] that there is significant difference in the academic retention of urban and rural students; the urban students' academic achievement was higher than that of their rural counterparts.

The finding of this study also established no significant interaction effect of method and school location on students' achievement in organic chemistry. This finding agrees with [22] that there is no statistically significant interaction effect of method and location on students' academic achievement in chemistry. The fact that this present study found no significant interaction effect of method and location on students' academic achievement in organic chemistry is a proof to the fact that method do not depend on school location to be effective.

CONCLUSION

The major causes of students' poor academic performance in chemistry have been attributed to, among other things; the use of ineffective teaching methods/strategies by teachers and the apparent difficulty associated to organic chemistry by students. These have resulted to persistent poor academic performance being recorded in both internal and external examinations by the chemistry students in Nigeria.

This therefore calls for an improvement on the mode and methods of teaching and learning of the subject, which necessitated this present study to try other alternative strategies of teaching chemistry, different from the conventional method. Moreover, this study lends empirical support to the fact that students' achievement in organic chemistry could be greatly improved when taught with the Learning Activity Package (LAP) which is an individualised method of instruction, among other innovative, student-centred and activity-based teaching methods. These innovative teaching methods have been proven to be effective in facilitating students' academic achievement in chemistry better than the lecture method, as supported by the findings of this study. The findings further revealed no significant influence of school location on students' academic achievement in organic chemistry, thereby establishing the fact that when chemistry teachers expose the students to LAP, their academic achievement could be greatly improved irrespective of their school location. This study has lent empirical support to the fact that when chemistry teachers individualises instructions in the classroom, students' academic achievement will be greatly enhanced.

The researcher therefore advocates for the chemistry teachers to imbibe the use of student-centred and activity-based teaching methods such as the Learning Activity Package, and de-emphasize the use of lecture method in chemistry teaching and learning. Because, effective

teaching arising from the use of Learning Activity Package, had positive impact on students' understanding of chemistry concepts and gave rise to higher achievement in the subject.

RECOMMENDATIONS

The researcher recommends as follows;

1. Chemistry teachers should be encouraged to utilise the Learning Activity Package in their lesson deliveries in order to encourage active engagement and self-motivation among learners for enhanced academic achievement.
2. The Learning Activity Package should be incorporated into the chemistry curriculum of teacher training tertiary institutions, so as to popularize its use among the teacher trainees in order to bring about enhanced achievement in chemistry in the secondary schools.
3. Secondary school chemistry curriculum should be reorganised in such a way as to incorporate the LAP into the system. This will enable the students to identify problems, stimulate their thinking ability and allow them to individually approach and solve chemistry problems.
4. Chemistry teachers should be encouraged to attend regular workshops and seminars to acquire the requisite skills to enable them make effective use of the Learning Activity Package in their lesson delivery.

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APPENDICES: SUPPLEMENTARY MATERIALS

Appendix A: LEARNING ACTIVITY PACKAGE MANUAL

LEARNING ACTIVITY PACKAGE MANUAL FOR SENIOR SECONDARY SCHOOL TWO (SSII) STUDENTS ON ORGANIC CHEMISTRY

INSTRUCTIONS:

This Learning Activity Package Manual (LAPM) is specifically designed to expose you to contents and activities in organic chemistry, for effective learning.

You will be provided with all necessary information to enable you achieve the purpose. You will go through the package step by step at your own pace. You will also be required to complete each learning activity, record your observations and thereafter respond to the questions that follow. You

are free to request for assistance from your teacher on areas you might experience some difficulties during the lesson.

The performance objectives of each topic are stated at the beginning of each lesson to enable you have a focus of what you are required to achieve by the end of the lesson. You are expected to keep good record of your work.

WEEK 1: Lessons One

TOPIC: Organic Chemistry

Sub-topic: Structure and valency of carbon

Duration: 4 periods (40 minutes per period)

Pre-Test:

Answer the following questions;

1. List 4 different forms in which carbon can exist?
2. What is the valency of carbon?
3. Give 4 reasons why carbon can combine with many substances?
4. Draw the tetrahedral structure of carbon?

Performance Objectives

By the end of the lesson, you should be able to;

1. List the different forms carbon can exist;
2. Determine the valency of carbon;
3. Explain why carbon can combine with many substances;
4. Draw the tetrahedral structure of carbon.

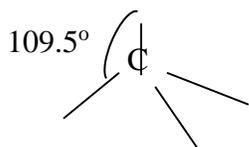
Concept

Carbon

Carbon is the name for the element with atomic number 6 and is represented by the symbol C. Carbon has 6 protons, 6 neutrons and 6 electrons. It is a non-metal that belong to group 4 in the periodic table. It occurs naturally as diamond and graphite in a pure form. Carbon also occurs in an impure form as coal; it occurs in the combined state as petroleum, wood and natural gases. Other sources that contain carbon are mineral deposits of metallic trioxocarbonates(iv) eg. Calcium trioxocarbonate(iv), limestone, and Magnesium trioxocarbonate(iv), dolomite; Carbon(iv)oxide in air and water; Charcoal which is of various forms or types eg. Wood charcoal, animal charcoal, sugar charcoal, etc; Coke, which is obtained by heating coal in the absence of air to a very high temperature otherwise known as the destructive distillation of coal; and finally soot or carbon black (lamp black).

Structure and valency of carbon:

The carbon atom has four unpaired valence electrons in its outermost (L) shell. This enables the carbon atom to form four single covalent bonds by sharing electrons with neighbouring atoms, which may be carbon atoms or atoms of other elements, so that the outermost shell of its atom is completely filled. The four covalent bonds of carbon are directed symmetrically in space at an angle of 109.5° to one another, i.e. they are arranged in a tetrahedral form, so that they point towards the corners of a regular tetrahedron when the carbon atom is placed in its centre.



Reasons why carbon can form numerous stable organic compounds:

1. Catenation: this is the ability of atoms of the same element to form long chains or rings. Carbon is unique in its ability to form very long chains, branched chains or ring compounds.
2. Multiple bonds: carbon is the only element in group (iv) which forms stable double and triple bonds to itself and to oxygen, sulphur and nitrogen.
3. When carbon has filled shell, it has no lone pair of electrons and cannot act as donor, because strong bonds are formed and this results in lack of reactivity of many carbon compounds.
4. The ease with which carbon combines with hydrogen, nitrogen and the halogens.
5. The ability of carbon atoms to form single, double or triple bonds and the strong carbon-carbon bonds formed.

Learning Activity 1.1

Construction of 3 dimensional model/structure of Carbon Atom

Materials: Coloured (Styrofoam) balls, poster board/cardboard paper, compass, glue, plasticine, pair of scissors and string.

Method/Procedure

1. Get 12 styrofoam balls of different colours (6 of one colour for the protons and 6 of another colour for the neutrons) and 6 small plasticine balls for the electrons.
2. Glue the six protons and six neutrons into a ball, alternating between protons and neutrons as you glue.
3. Cut a small ring and a large ring out of cardboard paper. Use string to tie these rings in concentric circles around [the nucleus](#).
4. Glue/place two electrons to the inner circle and four to the outer circle.
5. Attach string to the outer circle for hanging.

Learning Activity questions

Answer the followings questions;

- a. Why did you glue the protons and neutrons together?
- b. Why did you not glue the electrons together with the proton and neutron?
- c. What charge has the proton, neutron and electron?
- d. What does the small and large cut cardboard paper rings represent?

Self-Test / Evaluation

Answer the following questions;

1. Give 4 reasons why carbon can combine with many substances?
2. Draw the tetrahedral structure of carbon?
3. List 4 different forms in which carbon can exist?
4. What is the valency of carbon?

Mastery / Post-test;

Answer the following questions;

1. What is carbon?
2. Draw the electronic structure of carbon?
3. What are the forms in which carbon can exist in the pure state?

Enrichment Opportunities

Study pages 512 – 513 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 136 – 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

WEEK 2: Lesson Two

TOPIC: Organic Chemistry

Sub-topic: Hydrocarbons, Isomerism, Homologous series, Functional groups and Nomenclature

Duration: 6 periods (40 minutes per period)

Pre-test:

Answer the following questions;

1. What are hydrocarbons?
2. Define the term isomerism and give 3 examples?
3. What is homologous series?
4. Define functional groups and give 4 examples?
5. What are the procedures for naming an organic compound?

Performance objectives

By the end of the lesson, you should be able to;

1. Explain the meaning of hydrocarbons;
2. Give the definition of isomerism and some examples;
3. Explain the meaning of homologous series;
4. Define the term functional groups and give some examples;
5. Outline the procedures for naming organic compounds.

Concept

Hydrocarbons

Hydrocarbons are organic compounds composed only of two elements, carbon and hydrogen, just as their name imply. They are among the simplest organic compounds. They have the general molecular formula of C_xH_y , where x and y are whole numbers. The hydrocarbons are among the simplest organic compounds. Some examples are; Methane CH_4 , Propane C_3H_8 , Pentane C_5H_{12} , Benzene C_6H_6 , etc.

The hydrocarbons are classified into two main groups; Aliphatic and Aromatic hydrocarbons.

The Aliphatic hydrocarbons

These are organic compounds composed of carbon-carbon chains. They could be straight chain, branched chain or in the form of a ring.

They are sub-divided into two, based on the structure; Acyclic and Cyclic aliphatic hydrocarbons. In the Acyclic aliphatic hydrocarbons, the carbon atoms are joined together to form long straight or branched chains.

In the Cyclic aliphatic hydrocarbons, the carbon chains join together at the ends to form a ring.

The Aromatic Hydrocarbons

Aromatic hydrocarbons are special class of cyclic compounds based on benzene, C_6H_6 , a 6-carbon ring compound. All other aromatic compounds are derivatives of benzene, e.g phenylamine (aniline) and phenol. Some derivatives may also contain straight carbon chains as side chains.

Learning Activity 2.1

Making 3D Models of Hydrocarbons

Materials Needed/Apparatus:

Black coloured plasticine, White coloured plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.
2. The black plasticine balls will represent carbon atoms while the white plasticine balls will represent hydrogen atoms.
3. The match stick or toothpick will serve as bond.
4. Push single stick into the carbon atom at 4 different positions making sure that the bonds are tetrahedrally oriented.
5. Push hydrogen atom (white ball) into each of the bonds (stick).
6. Using the above method, make models of the following hydrocarbons
 - i. Methane (CH_4), ii. Propane (C_3H_8). iii. Pentane (C_5H_{12}).

Isomerism

Isomerism is the existence of two or more compounds that have the same molecular formula (the same number and types of atoms) but possessing different molecular structure (structural formula) and different properties. There are structural isomers, geometric isomers, optical isomers and stereoisomers.

Learning Activity 2.3

Making 3D Structures of examples of homologous series

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.
2. The black balls for carbon atoms, white balls for hydrogen atoms, brown ball for oxygen atom.
3. The match stick or toothpick for bonds.
4. Using the atoms (plasticine balls) and bonds (match sticks or tooth picks), construct a model of the following members of homologous series;
 - i. Alkene (Eg. Ethene, $\text{H}_2\text{C} = \text{CH}_2$) ii. Alkanol (Eg. Ethanol, $\text{H}_3\text{C} - \text{CH}_2\text{OH}$)
 - iii. Carboxylic acid (Eg. Ethanoic acid, $\text{H}_3\text{C} - \text{COOH}$) note that in the structure, 1 oxygen is double bonded to the carbon while the other oxygen is single bonded to carbon and hydrogen.

Functional group

A functional group is an atom, a radical or bond common to a homologous series and which determines the main chemical properties of the series. If there are two or more functional groups in one molecule of a compound, the properties of one are often modified or influenced by the presence of the other.

Examples of functional groups will include; Hydroxyl group – OH, Amino group – NH_2 , Carboxyl group – COOH, Amides – CONH_2 , Double bonded carbon atoms $\text{C} = \text{C}$, etc.

The functional groups determine the basic chemistry of a compound, i.e. it is the functional group that determines the chemical behaviour or characteristics of an organic compound. The functional group is based on the principle that, the chemical properties of a homologous series will change when a functional group is attached to a homologue and that the chemical properties of such homologue will be reflecting the chemical properties of the functional group attached. For instance, if a halogen is attached to an alkane homologous series, the series will change to haloalkane homologous series and the chemical properties of the haloalkane homologous series will be different from those of the alkane homologous series.

IUPAC Nomenclature of Hydrocarbons (IUPAC – International Union of pure and applied chemistry)

The IUPAC has put forward a system of naming the organic compounds which relates the name of the compound to its molecular structure. In this system of nomenclature, every name consists of; a root, suffix, and as many prefixes as necessary.

1. The root name is generally an aliphatic hydrocarbon. The systematic name of a compound is formed from the root hydrocarbon by adding a suffix and prefixes to denote the substitution of the hydrogen atoms by an alkyl, functional groups or multiple bonds.

2. The suffix(es) is/are added to the root to indicate the presence of the principal substituent which is usually also the principal functional group in the molecule. Compounds that have the same functional groups such as those belonging to the same homologous series, would carry a common suffix at the end of their names. Examples are; Alkanes end with –ane eg. Methane (CH_4), Ethane (C_2H_6) etc.; Alkenes end with –ene eg. Ethene (C_2H_4), Propene (C_3H_6) etc.; Alkanols end with –ol, eg. Methanol (CH_3OH), Ethanol ($\text{C}_2\text{H}_5\text{OH}$) etc.

Note that a suffix is a sound or syllable(s) added at the end of a word to make another word.

3. The prefix(es) are syllable(s) added in front of the root name of an organic compound.

Cyclic compounds can be indicated by adding the prefix cyclo – to the names of the corresponding aliphatic compounds eg. Cyclopentane, Cyclohexane, Cyclobutane etc.

4. Prefixes also used to indicate the presence of substituted alkyl or functional groups other than the principal group, as well as the positions of the substituents in the carbon chain. When more than one of the same substituent group is present, the multiplying prefixes such as di – for 2, tri – for 3, tetra – for 4 etc. are used. If more than one prefix is needed, they are placed in alphabetical order.

5. The positions of the substituent groups and the multiple bonds in the carbon chain of a compound are indicated by the number of the carbon atom or atoms to which they are attached. In numbering the carbon atoms, number all the carbon atoms in the longest chain starting from the end which is closest to the branch chain or other modifications of the simple alkane structure.

Rules of Naming Organic Compounds

- i. Take the longest continuous carbon chain as the root hydrocarbon and name it according to the number of carbon atoms it contains, adding the appropriate suffix to indicate the principal substituent group.
- ii. Number the carbon atoms in the root hydrocarbon from the end which will give the lowest number to the suffix and then the prefix(es).
- iii. Indicate the other substituents by prefixes preceded by numbers to show their positions on the carbon chain.

Examples of IUPAC names of Organic Compounds

- | | | | |
|------|--|-----|---|
| i. | $\text{CH}_3 - \text{CH}_2 - \text{CH}(\text{CH}_3) - \text{CH} = \text{CH}_2$ | ii. | $\text{CH}_3 - \text{CH}_2 - \text{C}(\text{CH}_3) = \text{CH} - \text{CH}_3$ |
| | 3-Methylpent-1-ene | | 3-Methylpent-2-ene |
| iii. | $\text{Cl} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{OH}$ | iv. | $\text{H} - \text{C}(\text{Cl}, \text{Cl}) - \text{CH}(\text{Cl}, \text{Cl})$ |
| | 3-Chloropropan-1-ol | | 1,1,2,2 Tetrachloroethane |

Learning Activity 2.4

Making 3D Models of Organic Compounds

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Using the different atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following organic compounds;
 - i. 3-methylpent-1-ene
 - ii. 3-methylpent-2-ene
 - iii. 3-chloropropan-1-ol
 - iv. 1,1,2,2 Tetrachloroethane

Self-Test / Evaluation

Answer the following questions;

1. What is homologous series?
2. What are the procedures for naming an organic compound?
3. Define functional groups and give 4 examples?
4. Define the term isomerism and give 3 examples?
5. What are hydrocarbons?

Mastery / Post-test;

Answer the following questions;

- i. Draw the structure of Cyclohexane
- ii. Draw the structure of Ethanoic acid

Enrichment Opportunities

Study pages 514 – 523 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

WEEK 3: Lesson Three

TOPIC: Hydrocarbons

Sub-topic: Saturated and Unsaturated hydrocarbons, Aliphatic hydrocarbons (Alkanes; properties, preparation and uses)

Duration: 6 periods (40 minutes per period)

Pre-test:

Answer the following questions;

1. When is a hydrocarbon compound said to be saturated?
2. Give 3 examples each of saturated and unsaturated hydrocarbons?
3. What is the general formula of the Alkanes?
4. Outline 3 properties of the Alkane homologous series?
5. Explain two methods of preparing the Alkanes?
6. List 5 uses of the Alkanes?

Performance objectives

By the end of the lesson, you should be able to;

1. define saturated and unsaturated hydrocarbons;
2. give examples of hydrocarbons which are saturated and those which are unsaturated;
3. give the general formula of the Alkanes;
4. list all the properties of the Alkane homologous series;
5. explain the methods of preparing the Alkanes in the laboratory; and
6. identify the uses of the Alkanes.

Concept

Saturated and Unsaturated Hydrocarbons

A saturated hydrocarbon is a compound in which the carbon atoms are joined together by single covalent bonds. They are hydrocarbons that contain only single carbon-carbon bonds. They are called the Alkanes (Eg. Methane (CH₄), Ethane (C₂H₆), Propane (C₃H₈) etc).

An unsaturated hydrocarbon is a compound which contains carbon atoms joined together by double or triple covalent bonds. Unsaturated hydrocarbons contain double or triple carbon-carbon bonds. They are the Alkenes (Eg. Ethene (C₂H₄), Propene (C₃H₆), etc.) and the Alkynes (Eg. Ethyne (C₂H₂), Propyne (C₃H₄), etc.).

Aliphatic Hydrocarbons – The Alkane homologous series

The alkanes are aliphatic hydrocarbons whose molecules have very similar structures to each other. They form a homologous series of saturated hydrocarbons whose general molecular formula can be represented as C_nH_{2n+2}, where n is an integer greater than or equal to +1.

The alkanes are hydrocarbons in which the constituent carbon atoms are tetrahedrally bonded by single covalent bonds to the hydrogen atoms and other carbon atoms.

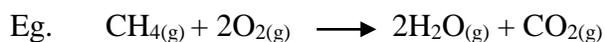
Below are molecular formula, structural formula and names of some members of the alkane homologous series, including the isomers. They are arranged in increasing molecular weight.

Molecular Formula	Structural Formula and Isomers	Name
CH ₄	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	Methane
C ₂ H ₆	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	Ethane
C ₃ H ₈	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$	Propane

C ₄ H ₁₀	$ \begin{array}{cccc} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\ & & & & \\ & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ $ \begin{array}{cccc} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\ & & & \\ & \text{H} & \text{H} & \text{H} \\ & & & \\ & \text{H} & & \end{array} $	<p>Butane</p> <p>2-methylpropane</p>

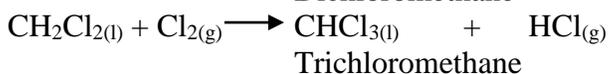
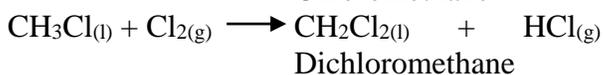
Properties of Alkanes

Combustion; the alkanes burn in oxygen (air) to give out heat, carbon(iv)oxide and steam.



Other reactions of alkanes;

Alkanes are generally unreactive because their molecules are non-polar and contain single covalent bonds. But the only reaction they undergo is the substitution reaction, in which another atom substitutes a hydrogen atom from the alkane compound. Eg. In the reaction between methane and chlorine, an atom of chlorine is substituted for a hydrogen atom in the methane molecule as shown below;



Methods of Preparation

The alkanes can be prepared in the following methods;

1. All the alkanes can be obtained by the fractional distillation of crude oil. Although the main source of methane is natural gas.
2. They can also be prepared in the laboratory by de-carboxylation (removal of CO₂) of the appropriate carboxylic acid.
3. They can also be prepared by heating an appropriate sodium salt with soda-lime.

Uses of Alkanes

- i. The alkanes are used mainly as fuels. For instance, CH_4 is the main component of natural gas while butane is the main component of camping gas and lighter fuel. Octane is an important component of petrol.
- ii. They are also used to produce very useful unsaturated hydrocarbons such as ethane (C_2H_4) through the process of cracking.
- iii. Methane is used for making hydrogen, carbon black, carbon(iv)sulphide, alkynes, hydrocyanic acid, trichloromethane (chloroform, an anaesthetic used in surgical operations), dichloromethane (CH_2Cl_2 used for dissolving paints) and tetrachloromethane (an important organic solvent used for removing grease stains).

Learning Activity 3.1

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkane compounds;
 - i. Propane
 - ii. Butane
 - iii. 2-methylpropane
2. Draw the structural formula of the following alkane compounds;
 - i. Pentane (C_5H_{12})
 - ii. 2-methylbutane (C_5H_{12})
 - iii. 2,2-dimethylpropane (C_5H_{12})

Self-Test / Evaluation

Answer the following questions;

1. List 5 uses of the Alkanes?
2. What is the general formula of the Alkanes?
3. Explain two methods of preparing the Alkanes?
4. Outline 3 properties of the Alkane homologous series?
5. Give 3 examples of saturated and unsaturated hydrocarbons?
6. When is a hydrocarbon compound said to be saturated?

Mastery / Post-test;

Answer the following questions;

1. What is substitution reaction in alkanes?
2. Give 3 differences between saturated and unsaturated hydrocarbons?
3. Give 3 examples each of acyclic and cyclic aliphatic hydrocarbons?

Enrichment Opportunities

Study pages 524 – 527 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 137 – 140 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

WEEK 4: Lessons Four and Five**TOPIC:** Hydrocarbons**Sub-topic:** Alkenes and Alkynes (properties, preparations and uses)**Duration:** 6 periods (40 minutes per period)**Pre-test:**

Answer the following questions;

1. What are the general molecular formula of the alkenes and alkynes?
2. Why are alkenes and alkynes said to be unsaturated?
3. List the methods of preparing the alkenes and the alkynes?
4. Draw the structures of 4 examples of alkene homologous series?
5. Draw all the isomers of hexyne?

Performance objectives

By the end of the lessons, you should be able to;

1. write the general molecular formula of the alkenes and alkynes;
2. explain unsaturation in the alkenes and alkynes;
3. explain the methods of preparing alkenes and alkynes;
4. identify the structures of alkene homologous series; and
5. explain isomerism in hexyne.

Concept

Lesson Four:

The Alkene homologous series

The alkenes are homologous series of hydrocarbons with a general molecular formula of C_nH_{2n} , where n is a positive integer equal to or greater than 2. They contain 2 hydrogen atoms less than the alkanes. The alkenes are unsaturated hydrocarbons which contain a carbon-carbon double bond as well as single bonds. The alkenes are given names similar to the alkanes depending on the number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -ene.

Below are molecular formula, structural formula and names of some members of the alkene homologous series, including the isomers. They are arranged in increasing molecular weight.

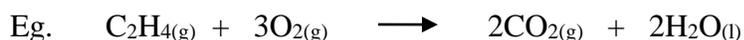
Molecular Formula	Structural Formula and Isomers	Name
C_2H_4	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}=\text{C}-\text{H} \end{array}$	Ethene

C_3H_6	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	Prop-1-ene
C_4H_{10}	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}=\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	But-1-ene But-2-ene 2-methylprop-1-ene

Properties of Alkenes

Combustion:

The alkenes burn to give carbon(iv)oxide and water, with a smoky and luminous flame because of the high proportion of carbon.



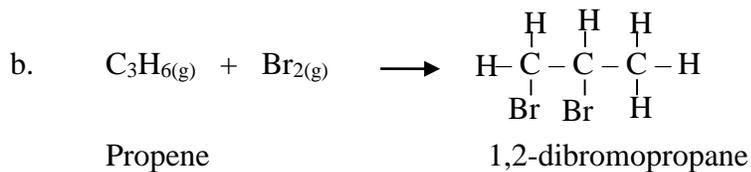
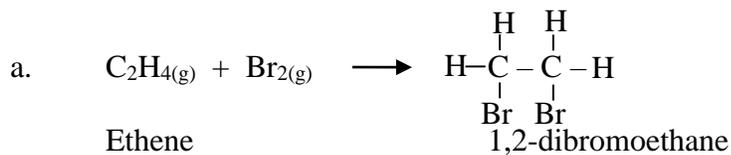
Other reactions of alkenes;

The alkenes are generally more reactive than the alkanes because of the double bond in their structure which make them unsaturated compounds.

Addition Reactions of Ethene (C_2H_4) and Propene (C_3H_6) with Bromine.

Due to their unsaturated nature, the alkenes react by addition, which means specie is simply added on as shown in the following examples;

1. Addition Reactions of Ethene and Propene with Bromine;



Polymerisation:

The alkenes undergo polymerisation especially ethene and its derivatives to form important compounds such as polyethene, polychloroethene, etc.

Polymerisation is a process whereby many simple molecules known as monomers are linked to form a much larger molecule known as a polymer.

Methods of Preparation:

1. The main commercial source of the alkenes is from the thermal or catalytic cracking of larger alkane molecules. In the process, mixtures of alkenes are obtained which are separated by fractional distillation. Eg. $C_{12}H_{26} \rightarrow C_8H_{18} + C_4H_{10}$



2. Another method used in the preparation of alkenes involves dehydration of the appropriate alcohol. Eg. Ethene can be prepared by heating ethanol with conc. tetraoxosulphate (vi) acid (H_2SO_4).

**Uses of Alkenes:**

1. The cracking of petroleum produces large quantities of ethene for industrial uses such as polyethene products.
2. Propene is used to produce plastics such as Perspex.
3. Buta-1,3-diene is used in synthetic rubber manufacture.

Learning Activity 4.1**Materials Needed/Apparatus:**

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkene compounds;
 - i. Ethene
 - ii. But-1-ene
 - iii. 2-methylprop-1-ene
2. Draw the structural formula of the following alkene compounds;
 - i. Hex-2-ene (C_6H_{12})
 - ii. Hept-3-ene (C_7H_{14})
 - iii. 3,3-dimethylhept-1-ene (C_9H_{18})

Lesson Five:**The Alkyne homologous series**

The alkynes are groups of hydrocarbons which belong to the same homologous series. They have a general molecular formula of C_nH_{2n-2} , where n is a positive integer equal to or greater than 2. Each alkyne molecule contains four (4) hydrogen atoms less than the corresponding alkane and two (2) hydrogen atoms less than the corresponding alkene. The alkynes are unsaturated hydrocarbons which contain a carbon-carbon triple bond as well as single bonds in each molecule. They show a higher degree of unsaturation than the alkenes and are therefore more reactive than the alkenes and the alkanes. The alkynes are given names similar to the alkanes depending on the

number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -yne.

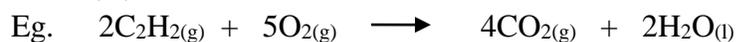
Below are molecular formula, structural formula and names of some members of the alkyne homologous series, including the isomers. They are arranged in increasing molecular weight.

Molecular Formula	Structural Formula and Isomers	Name
C ₂ H ₂	H-C≡C-H	Ethyne
C ₃ H ₄	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}\equiv\text{C}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	Prop-1-yne
C ₄ H ₆	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}\equiv\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \quad \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}\equiv\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \quad \quad \text{H} \end{array}$	But-1-yne But-2-yne

Properties of Alkynes

Combustion:

1. The alkynes (ethyne) burns in air to give a very smoky and luminous flame to form carbon(iv)oxide and water.



2. If ethyne is used in a special burner with an extra oxygen supply, it burns brilliantly giving the very hot oxy-acetylene (oxy-ethyne) flame which is capable of cutting through metals.

3. When a sample of ethyne is tested with a lighted taper, it burns with a yellow, sooty flame owing to its high carbon content and carbon is deposited.



Other reactions of alkynes:

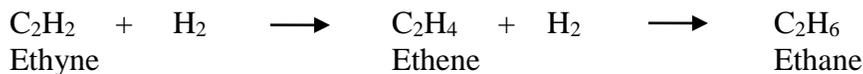
Addition Reactions;

Alkynes are highly unsaturated, containing carbon-carbon triple bond in its structure. They undergo addition reactions combining with a maximum of four (4) univalent atoms or radicals per molecule to form addition products. The addition reactions take place in two stages;

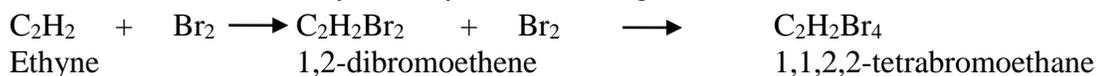
- The first stage yields a product with a carbon-carbon double bond ie. Alkenes.
- The second stage converts this into a fully saturated compound with only carbon-carbon single bonds ie. Alkanes.

Examples

1. Addition reaction of Alkyne (Ethyne) with Hydrogen



2. Addition reactions of Alkyne (Ethyne) with Halogens (Bromine, Br₂)



Chlorine reacts explosively with ethyne producing carbon and hydrogen chloride gas



Ethyne reacts with Chlorine and Bromine in the presence of a catalyst (metallic halide) to yield halogenated compounds at room temperature.

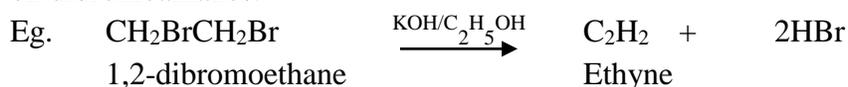
Polymerisation

Alkynes also polymerises especially, ethyne which polymerises to form the aromatic hydrocarbon, benzene (C₆H₆) when it is passed through a hot tube containing a complex organo-nickel catalyst.

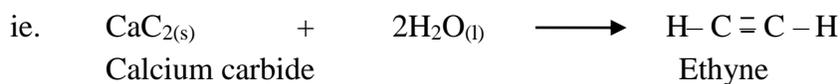


Methods of Preparation:

1. alkynes can be prepared in the laboratory by the action of alcoholic potassium hydroxide on dibromoalkanes.



2. However, ethyne can be prepared in the laboratory conveniently by the action of cold water on calcium carbide.



Uses of Alkynes:

1. Ethyne is used as the starting material for the production of Polyvinylchloride (PVC), 1,1,2,2-tetrachloroethane (a solvent for grease and oils), artificial or synthetic fibres and ethanoic acid.
2. Ethyne is used in the oxyacetylene torch and in lamps.

Learning Activity 4.2

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkyne compounds;
 - i. Ethyne
 - ii. Prop-1-yne
 - iii. But1-yne
 - iv. But-2-yne
2. Draw the structural formula of the following alkyne compounds;

- i. Pent-2-yne (C_5H_8). ii. Hex-3-yne (C_6H_{10}). iii. 3,5-dimethylhept-1-ene (C_9H_{16}).

Self-Test / Evaluation

Answer the following questions;

1. What are the general molecular formula of the alkenes and alkynes?
2. Why are alkenes and alkynes said to be unsaturated?
3. List the methods of preparing the alkenes and the alkynes?
4. Draw the structures of 4 examples of alkene homologous series?
5. Draw all the isomers of hexyne?

Mastery / Post-test;

Answer the following questions;

1. What are aromatic hydrocarbons?
2. Draw the resonating structures of benzene?
3. In a tabular format, distinguish between the alkanes, alkenes and alkynes?

Enrichment Opportunities

Study pages 528 – 535 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 149 – 154 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

Appendix B: Chemistry Achievement Test on Organic Chemistry (CATOC)

Section A

Name of school:.....

Name of student:.....

Class:.....

Sex: Male Female (Tick ✓)

Section B

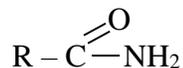
Instructions

- a. Choose and tick only the correct answer from options a - d
- b. Erase completely any answer made in error
- c. Do not cheat in any form
- d. Time allowed is 1.30 hrs
- e. Answer all the questions.

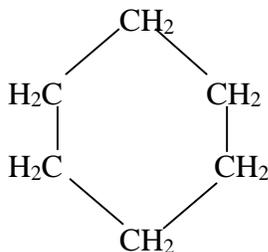
Questions

1. The following are general characteristics of carbon except?
 - a. covalent nature and non-polar.
 - b. low melting and boiling points
 - c. low reactivity with other elements except oxygen and the halogens
 - d. hydrogen bond in petrol
2. Exceptional large number of carbon compounds is essentially due to the ability of?
 - a. carbon to catenate liberally
 - b. various groups to catenate

- c. nitrogen, hydrogen, phosphorous and the halogens to catenate with themselves
 d. hydrocarbons to dominate other groups
 3. What is the name of $C(CH_3)_4$?
 a. butane b. tetramethyl butane. c. methyl propane. d. 2,2-dimethyl propane
 4. What is the name of the homologous series with the general formula shown below?



- a. amine. b. amino acids. c. oxy-amines. d. amides.
 5. Which is not among the characteristics of functional groups in organic compounds?
 a. determine the chemical properties of the homologous series
 b. does not modify the other when they are more than one in a molecule
 c. have a general formula which may include the functional group
 d. are responsible for the physical properties
 6. The IUPAC name of $ClCH_2-CH_2-CH_2OH$ is?
 a. 1-chloropropan-3-ol. b. 3-chloropropan-1-ol. c. 1-chloropropanol.
 d. 3-chloropropanol.
 7. Which of these compounds is not a hydrocarbon?
 a. benzene b. ethane c. ethanol d. butyne
 8. What is the name given to the compound shown below?



- a. benzene b. hexane c. cyclohexane d. hydrobenzene
 9. When two or more compounds have the same molecular formula but different structures they are known as?
 a. allotropes. b. tautomerism. c. mirror isomers. d. structural isomers.
 10. Which is not among the uses of Petroleum?
 a. fuels only. b. fuels and money. c. fuels and pollutants.
 d. fuels and petrochemical raw materials
 11. The main natural sources of hydrocarbons are from fossil fuels and these include except?
 a. natural gas b. coke c. coal d. petroleum
 12. Alkenes and Alkynes reacts the same, except with?
 a. ammoniacal $AgNO_3$ solution. b. oxygen. c. bromine water.
 d. acidified $KMnO_4$ solution.
 13. Functional group for the alkanol is?
 a. $-OH$. b. C_nH_{2n-2} c. $COOH$ d. OH^-
 14. What is this compound $CH_3(CH_2)_2CONH_2$ called?
 a. methyl amine. b. butyl amine. c. butyl amide. d. Urea.
 15. Which among the following is an aromatic hydrocarbon?
 a. cyclopentane b. toluene c. pentanal d. ethane
 16. What is the product formed when methane reacts with chlorine; $CH_4 + Cl_2 \rightarrow ?$
 a. $CH_4Cl_2 + H_2$ b. $CH_3Cl + HCl$ c. $CH_2Cl + 2HCl$ d. $CH_2Cl_2 + H_2$

17. Which of the following compounds is an alkane?
a. C_2H_2 b. C_3H_6 c. C_4H_6 d. C_6H_{14}
18. What type of reaction takes place when ethane reacts with hydrogen bromide?
a. oxidation reaction b. substitution reaction c. addition reaction
d. polymerisation reaction
19. Which of the following molecules is the most unsaturated?
a. ethyne b. methane c. ethene d. propane
20. Write the general formula for the alkynes?
a. C_nH_{2n} b. C_nH_{2n+2} c. C_nH_{2n-2} d. C_nH_{2n-n}
21. Hydrocarbons are organic compounds that contain....?
a. carbon and oxygen only. b. carbon, hydrogen and oxygen only.
c. carbon and sulphur only. d. carbon and hydrogen only.
22. Which method is often used in separating the hydrocarbons found in petroleum?
a. catalytic cracking b. polymerisation c. fractional distillation
d. hydrogenation
23. Which of the following compounds do not exhibit isomerism?
a. C_2H_6 b. C_4H_8 c. C_6H_{14} d. C_5H_8
24. What is the name of the compound C_2H_5COOH ?
a. ethanoic acid. b. propanoic acid. c. Butanoic acid. d. methanoic acid.
25. what is the general molecular formula of the alkene homologous series?
a. C_nH_n b. C_nH_{2n+2} c. C_nH_{2n} d. C_nH_{2n-2}

Appendix C: CATOC Marking Guide

1. d
2. a
3. d
4. d
5. b
6. b
7. c
8. c
9. d
10. c
11. b
12. b
13. a
14. c
15. b
16. b
17. d
18. b
19. a
20. c
21. d
22. c
23. a
24. b
25. c

Appendix D: TEST BLUE PRINT FOR THE CATOC

Content	Knowledge (Remembering) 45%	Comprehension (Understanding) 30%	Application (Thinking) 25%	Total
Structure and Valency of Carbon - 10%	A 1	B 1	C 1	T _a 3
Hydrocarbons (Saturated, Unsaturated, Alkanes, Alkenes and Alkynes) - 45%	D 5	E 3	F 3	T _b 11
Isomerism, Homologous series, Functional groups) 25%	G 3	H 2	I 1	T _c 6
IUPAC Nomenclature 20%	J 2	K 2	L 1	T _d 5
Total	T _e 11	T _f 8	T _g 6	25

Calculations:**Total number of items = 25**

From the table above, 'Structure and valency of carbon' was allotted 10%; 'Hydrocarbons (saturated, unsaturated, alkanes, alkenes and alkynes)' had 45%, 'Isomerism, Homologous series and Functional groups' had 25%; while IUPAC nomenclature was allotted 20%. Likewise, Knowledge was allotted 40%, Comprehension 35% and Application 25%.

Calculating the totals, T_a to T_g;

$$T_a = 10/100 \times 25 = 3 \qquad T_b = 45/100 \times 25 = 11$$

$$T_c = 25/100 \times 25 = 6 \qquad T_d = 20/100 \times 25 = 5$$

$$T_e = 45/100 \times 25 = 11 \qquad T_f = 30/100 \times 25 = 8$$

$$T_g = 25/100 \times 25 = 6$$

Calculating the number of items/questions for each cell, A to L;

$$A = 11/25 \times 3 = 1 \qquad B = 8/25 \times 3 = 1 \qquad C = 6/25 \times 3 = 1$$

$$D = 11/25 \times 11 = 5 \qquad E = 8/25 \times 11 = 3 \qquad F = 6/25 \times 11 = 3$$

$$G = 11/25 \times 6 = 3 \qquad H = 8/25 \times 6 = 2 \qquad I = 6/25 \times 6 = 1$$

$$J = 11/25 \times 5 = 2 \qquad K = 8/25 \times 5 = 2 \qquad L = 6/25 \times 5 = 1$$