Educational Research (ISSN: 2141-5161) Vol. 4(2) pp. 182-189, February 2013
Available online@ http://www.interesjournals.org/ER

Full Length Research Paper

Effects of concept mapping strategy on students' achievement in difficult chemistry concepts

Otor Eriba Emmanuel (PhD)

Department of Curriculum and Teaching, Benue State University, Makurdi, Nigeria.
E-mail: otoreribaemmanuel@gmail.com

Abstract

This study investigated the effects of concept mapping strategy on secondary school students' achievement on difficult chemistry concepts. It also examined the differential effect on the achievement of male and female chemistry students. Two research questions and two hypotheses were formulated to guide the research. The study used a quasi-experimental pretest-posttest on group design. Data were collected from 1,357 SS2 chemistry students using a stratified random sampling procedure from two schools in two local government Areas of Benue State of Nigeria. One instrument for data collection developed by the researcher and validated by experts was Chemistry Achievement Test (CAT), on structure of matter and energy changes. The research questions were answered using mean and standard deviation scores, while the hypotheses were tested at 0.05 significance level using Analysis of Covariance (ANCOVA). Students taught using concept mapping strategy achieved higher and significantly better than those taught using conventional method. There was also a better performance in favour of female students compared to their male counterparts using this method. The study recommended among other things, adequate training of chemistry teachers on the use of concept mapping strategy in teaching chemistry at the secondary school level.

Keywords: Concept mapping, Strategy, Achievement, Difficult chemistry concepts, structure of matter, Energy changes.

INTRODUCTION

Effective teaching is so crucial to learning that the products of teaching such as knowledge, attitude and skills acquisition are much dependent on the teacher's effective teaching. Effectiveness of a teacher and students learning can be enhanced through the appropriate strategy adopted in a learning situation. Effectiveness in chemistry teaching will bring about the expected change of behaviour and learning among chemistry students.

Chemistry is an experimental science; its study involves exploration of relationship between theory and experiment. Many of these theories are intimately associated with abstract concepts such as mole, atomic structure, energy level/energy quanta, periodicity, reaction rate and chemical equilibrium. Learners usually find it difficult to negotiate the correct meaning of these concepts. Even the use of models, charts, posters has not been sufficiently successful because of the very abstract nature of these concepts.

The country's desire to achieve the objectives of scientific and technological development has given rise to seek for appropriate ways of teaching science subjects. This investigation however is limited to chemistry as one of the science subjects. This is because chemistry is an important science subject that occupies a prominent place in the school science curriculum.

According to Akpan (2006), chemistry is the study of matter and the changes that matter undergoes. The author observed that secondary school students in Nigeria perform very poorly West African Examination Council (WAEC) and National Examination Council (NECO) yearly. The performance also in this subject among male and female students vary significantly in favour of male students (Otor, 2011; Gyuse, 1990).

Iyang and Ekpenyong (2000), Mari (2002), Njoku (2007) and Olayiwola (2007) all reported cases of students' poor differential performance among gender. It is in the light of these research documentations and authors' observation in deteriorating attainment of students in this subjects that this research work is asses-

sing the effectiveness in the teaching of chemistry.

Concept mapping was introduced by Novak of Cornell University and his collaborators in the late 70s. It is based on Ausubel's theory of subsumption of new ideas or concepts into an organized structure, a preexisting knowledge. It is believed that the new concepts are given meaning though assimilation into existing framework.

Construction of good concept mappings by students depends to a large extent, on effective planning and sequential teaching by the teacher (Ikeobi, 2010). The thought out and carefully spaced and the delivery of lesson should reflect the inter-relationship between various concepts. On completion of a series of lessons on the subsumer, for example, structure of matter and energy changes, the students are asked to construct concept mapping on the subsumer (super ordinate concept). If a group of students are able to produce a good concept mapping at the end of lessons, then one can safely conclude that some meaningful learning has occurred. Concept mapping provides opportunity for students to work in groups thereby encouraging cooperative learning (see Appendix A_1, A_2 and A_3).

In a study on cognitive style and students' problem-solving competence in chemistry, Ahiakwo (1991) reported that students perform poorly in qualitative problems involving electrolysis. The study emphasized that students not only had difficulties with the recall of appropriate information but also with the methods on strategies required to reason through the problem. The study was concerned with finding out the extent to which students' cognitive style influenced their problem solving ability in some aspects of chemistry. In this study, 226 SS, chemistry students from ten secondary schools in Ahoada area of River State were used for the study. The subjects consisted of 110 analytic style students and 116 non-analytic style students. The author emphasized the difficulties students faced in recalling appropriate information in a learning task and that they were also handicapped in applying appropriate methods or strategies. This study is therefore another step to helping chemistry students effectively use their cognitive skills to apply their previous learning experiences as well as the application of an expected useful strategy.

Humbly (1997) in London reported that of the 480 female and 20,000 male chemistry within 1964-65 in upper schools, only 15% of the farmer 45% of the letter obtained results that met the entry qualifications for university admission. Humbly's findings revealed that chemistry students' attainment was generally low hence needs further investigation (s). Issues as highlighted here add ingredients to this study.

Theoretical Bases for the Study

This research work is based on psychological theory of learning by Ausubel (1968). Ausubel is a cognitive psychologist who was concerned about how information can be made more meaningful so that it can be better understood and used. The study addressed the issue of meaningful learning and stressed the value of prior knowledge in students learning and linking of new information to existing schemes as a necessary requirement for meaningful learning.

According to Ausubel as cited in Abdulahi (1982) meaningful learning occurs where there is appropriate link between prior knowledge and new learning task. Meaningful learning is therefore the formation of viable relationships among ideas, concepts and information (Otor, 2011).

Statement of the Problem

Science teachers have applied various methods and strategies like discovery questioning, field trips, lecture and discussion (Akinsola and Igwe, 2002) for teaching chemistry, yet there has been poor performance among secondary school students in the certificate examination throughout the country (WAEC, 2002). This has denied many Nigerian students the opportunity of getting admitted into institutions of higher learning. There is therefore an out-cry from parents, teachers, curriculum planners and other stakeholders in educational industry about the deteriorating performance in both internal and external examination in Nigeria. Certain difficult chemistry concepts have also been identified to contributing to students poor performances as identified (Okebulela, 2005; WAEC, 2002). Topics such as "structure of matter" and "energy and energy changes" are considered difficult. It seems that concept mapping strategy could be an approach to effectively teach these concepts and enhance students achievement in chemistry. The objective of this study therefore was to find out if concept mapping strategy would provide solutions to the problems of understanding chemistry and enhance students' achievement.

Purpose of the Study

The purpose of this study is to determine the effects of using concept mapping strategy in teaching difficult chemistry concepts and students' achievement.

To achieve this purpose, the following specific objectives were persued:

i. To find out the effectiveness of using concept mapping strategy in teaching difficult chemistry concepts.
ii. To determine if the use of concept mapping strategy in teaching difficult chemistry concepts has the same effect on male and female students achievement in chemistry.

Table 1. Mean achievement scores and standard deviations of subjects in the experimental and control groups.

Group	No of subjects	pre-test		Post-test		Mean difference
		Mean	SD	Mean	SD	
Experimental	687	5.11	1.34	15.18	2.02	10.07
Control	670	5.06	1.34	10.84	1.65	5.78
Difference in mean			4.34			

Research Questions

The following research questions are answered by this study:

i. To what extent is the difference between the mean achievement scores of chemistry students taught using conventional method and those taught using concept mapping strategy?.
ii. Do male and female students perform equally well in chemistry when taught using concept mapping strategy?

Null Hypotheses

To determine the extent to which this strategy was effective in realizing the purpose of the study, the following hypotheses were tested at 0.05 significance level:

HO: There is no Significance difference in the mean achievement scores of senior secondary school chemistry students taught using concept mapping and those taught using the conversional method:

HO2: There is no significant difference between the mean achievement scores of male and female chemistry students taught using concept mapping.

METHODOLOGY

Quasi-experimental design was used for this study. A non- randomized control and experimental groups involving a pretest-posttest was applied. The experiment lasted for six weeks. The target population of this study was all SS2 chemistry students in Benue State. A sample of 1357 male and female chemistry students representing 12.27% of the total population of 11062 was used for the study.

One research instrument which was validated by experts in chemistry education, measurement and evaluation was design and used for this study namely: Chemistry Achievement Test (CAT). The instrument was pilotested to test their reliability and was found to be 0.81 hence reliable to the study. The CAT was made up of twenty items drawn from the difficult chemistry concepts, the structure of matter and energy changes. Two research assistants were trained and used for this study.

The researcher and the trained assistants were involved in the administration of the research instruments and collection of data. The research hypotheses were tested using Analysis of Covariance (ANCOVA) while the research questions were treated using means and standard deviations.

The researcher adapted White and Gunstone (2006) concept mapping procedure. The students were allow to brainstorm, organize, layout, linking and finalizing the concept map. Adapting these phases, the students constructed their own concept maps in groups.

RESULT AND DISCUSSION OF FINDINGS

The results and Discussion of Findings were made under the research questions and hypotheses using appropriate Tables.

Research Question 1

What is the difference between the mean achievement scores of chemistry students taught using lecture method and those taught using concept mapping strategy?

Table 1 shows that the mean achievement score of the experimental group in the post-test was 15.18 with a standard deviation of 2.02, which is higher than the mean of the control group of 10.84 and a standard deviation of 1.65.

To ascertain whether the observed difference was significant, hypothesis 1 was tested.

Null hypothesis One (Ho_1)

There is no significant difference in the mean achievement scores of senior secondary school chemistry students taught using concept mapping and those taught using the conventional method.

The results in Table 2 indicate that method is a significant factor in students' mean achievement in structure of matter and energy changes. Hypothesis one which stated that method is not a significant factor in students' achievement in chemistry is therefore rejected.

Table 2. Tests of Between-Subjects Effects (The results of the analysis of covariance for CAT).

Source	Type III Sum of Squares	Df	Mean square	F	Sig
Corrected Model	7519.605[a]	8	939.951	361.259	.000
Intercept	8230.140	1	8230.140	3163.160	.000
Pretest	930.572	1	930.572	357.655	.000
Group	6246.181	1	6246.181	2400.648	.000
Location	53.696	1	53.696	20.638	.000
Sex	38.239	1	38.239	14.697	.000
Group*Location	31.316	1	31.316	12.036	.001
Group* Sex	59.707	1	59.707	22.948	.000
Location*Sex	107.304	1	107.304	41.241	.000
Group*Location* *Sex	7.205	1	7.205	2.769	.096
Error	3507.325	1348	2.602		
Total	241740.000	1357			
Corrected Total	11026.930	1356			

R Squared = .682 (Adjusted R Squared = .680)

Table 3. Mean achievement scores and standard deviations of male and female subjects.

Method	Types of Test	Male		Female
		Mean	SD	Mean
Experimental	Pre-test	5.22	2.05	4.93
Group	post-test	14.95	1.92	16.56
Mean difference		9.73		11.63

This means that there is a significant difference in the mean achievement scores of students taught using concept mapping and those taught using the conventional method. The experimental group achieved significantly higher than the control group in the structure of matter and energy changes test. Hence, the use of concept mapping strategy influenced achievement in structure of matter and energy changes.

Research Question 2

What is the difference between the mean achievement scores of male and female students taught using concept mapping?

The results in Table 1 show that students in the experimental group had a higher achievement score in structure of matter and energy and energy changes compared with their control group counterparts. This is further confirmed by the results in Table 3 which indicate that method is a significant factor in the achievement of matter and energy and energy changes content among gender.

This means that the students who were taught using the concept mapping strategy performed better than those who were taught using the lecture method. The reason for this enhanced performance by the experimental group is that the students were able to link the new concepts to the relevant concepts they were previously acquainted with. The results of the study therefore reveal that the adoption of relevant instructional strategies will enhance meaningful learning of chemistry.

The results from Table 3 indicate that the female students performed better than their male counterparts. Testing for the significance, the results in Table 2 reveal that the difference in mean achievement of the male and female students is significant.

The results in Table 3 reveal that female students had higher mean score than their male counterpart. The mean achievement gain of 11.63 of the female students is higher than that of the male students with a gain of 9.73. Table 2 indicates that gender was a significant factor on students' achievement on structure of matter and energy changes. The Table reveals that female students had greater achievement score. Hence the use of concept mapping strategy enhanced the achievement of female chemistry students.

DISCUSSION OF FINDINGS

Results in Table 1 show that students in the experimental group had a higher achievement score in structure of matter and energy changes compared with their control group counterparts. This is further confirmed by the results in table 2 which indicate that method is a significant factor in the achievement of matter and energy changes content. This means that students who were taught using the concept mapping strategy performed better than those who were taught using the lecture method.

The results in Table 3 indicate that method is also a significant factor in the achievement of male and female students. Table 3 reveals that the female subject in the experimental group obtained a higher mean achievement of 16.56 in the post that with a standard deviation of 1.92 compared with their male counterparts who had a mean of 14.95 with a standard deviation of 2.05. It can be observed that both the male and female subject in the experimental group had higher mean achievement scores (14.95 and 16.56) in the posttest compared with their mean achievement scores of the pretest of 5.22 and 4.93 respectively. The reason for this enhanced performance by the e4xperiemental group is that the students were able to link the new concepts to the relevant concepts they were previously acquainted with.

CONCLUSION

The students who were taught using the concept mapping strategy performed better than those who were taught using the lecture method. Also the female students exposed to concept mapping performed better than their male counterparts in the achievement test. There was also a significant difference in the mean achievement scores of the male and female students in favour of the female. Students in rural schools in the experimental group performed better than the urban students.

RECOMMENDATIONS

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

a. Since concept mapping is found to be an effective teaching strategy for improving students' achievement in chemistry, chemistry teachers should accept it as one of the strategies they can use in chemistry classroom.
b. The teacher training institutions should include the concept mapping strategy in their chemistry method course content. This will ensure that pre-service chemistry teachers know the value of and how to use the concept mapping strategy.

REFERENCES

Abdullahi A (1982). Science teaching in Nigeria. Ilorin: Atoto Press Ltd.

Ahiakwo MJ (1991). Cognitive style and students' problem-solving competence in chemistry. J. Sci. Teachers Assoc. Nig. (STAN). 27 (1), 230-234.

Akinsola MK, Igwe IO (2002). The relative effect of metacognitive strategy of framing on students' achievement in selected difficult chemistry concepts. J. Sci. Teachers' Assoc. Nig. (STAN), 40, (1 and 2), 45-60.

Akpan EUU (2006). Critical and emerging issues in science, technology and mathematics education in Nigeria. A lead paper at a conference of colleges of education academic staff union, Gindiri, June 6-9.

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

Gyuse EY (1990). Conceptual demands of secondary school chemistry in relation to the students' reasoning level. An Unpublished Ph.D Thesis, University of Jos, Nigeria.

Humby SR (1997). Science and education. London: Cambridge; University Press and Barthey.

Ikeobi IO (2010). Beyond the Stereotype: Thoughts and Reflections on Education. Lagos Nigeria. The CIBN Press Limited.

Inyang NEU, Ekpenyong HE (2000). Influence of ability and gender groupings on senior secondary school chemistry students achievement on the concept of redox reactions. J. Sci. Teachers' Assoc. Nig. (JSTAN), 40 (1 and 2), 36 – 42.

Mari JS (2002). Gender related differences in acquisition of formal reasoning schemata: pedagogic implication of teaching chemistry using process-based approach. J. Sci. Teachers' Assoc. Nig. (JSTAN), 40 (1 and 2). 45-61.

Njoku ZCN (2007). Comparison of students' achievement in the three categories of questions in SSCE practical chemistry examination. J. Sci. Teachers Assoc. Nig. (JSTAN), 42 (1 and 2), 67-71.

Okebukola PA (2005). The race against obsolescence: Science Teachers' Association of Nigeria (STAN) memorial lecture series, 17. Enhancing the Relevance of STAN to National Development Jos, Plateau State, Nigeria.

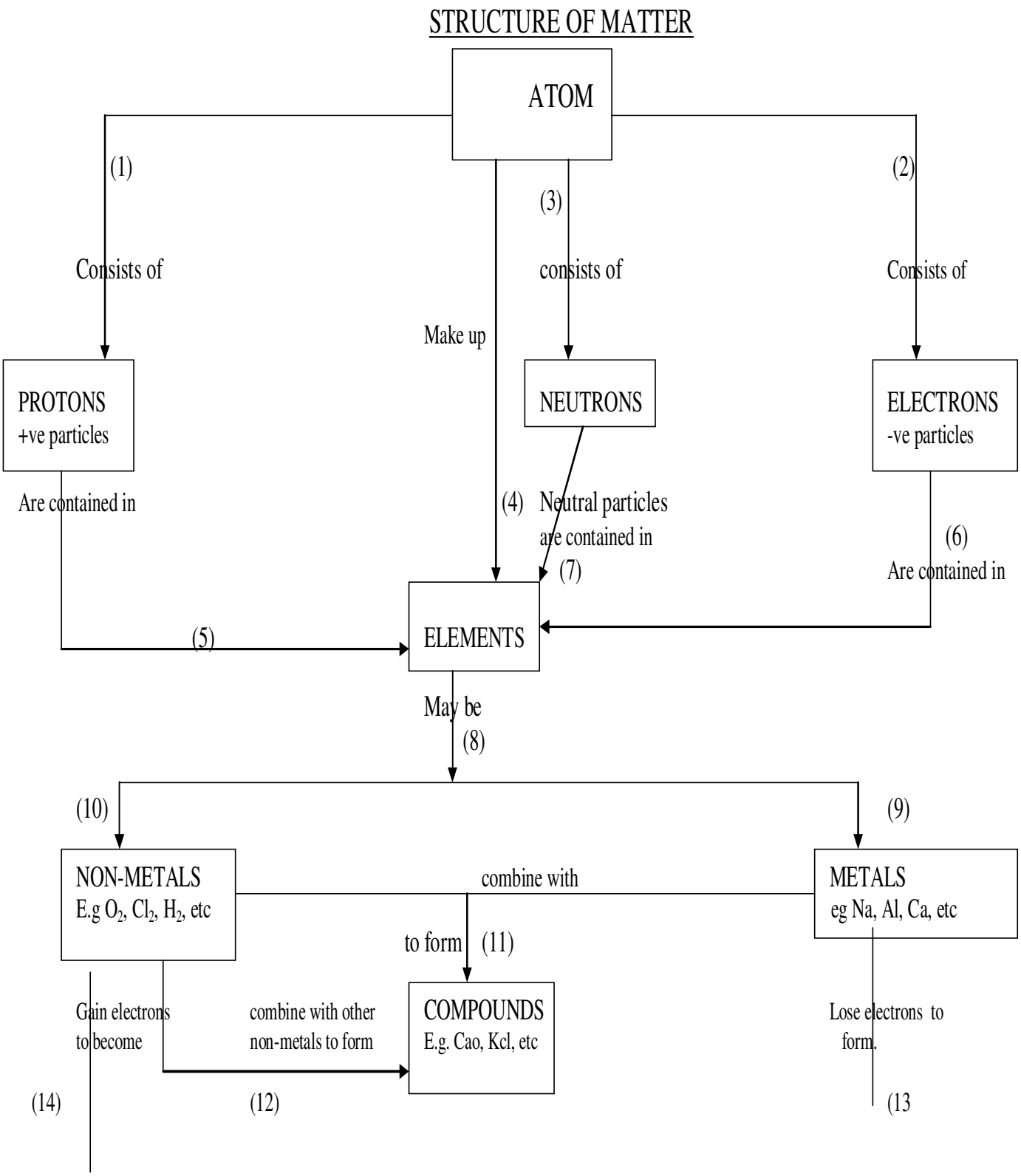
Olayiwola MA (2007). Teaching difficult concepts in chemistry effectively: The teacher's requirements. Chemistry panel series (STAN). Kano: Abioye dynamic printers.

Otor EE (2011). Effects of Concept Mapping Strategy on Students' Attitude and Achievement in Difficult Chemistry Concepts. A PhD Thesis Submitted to the Postgraduate School, Benue State University Makurdi.

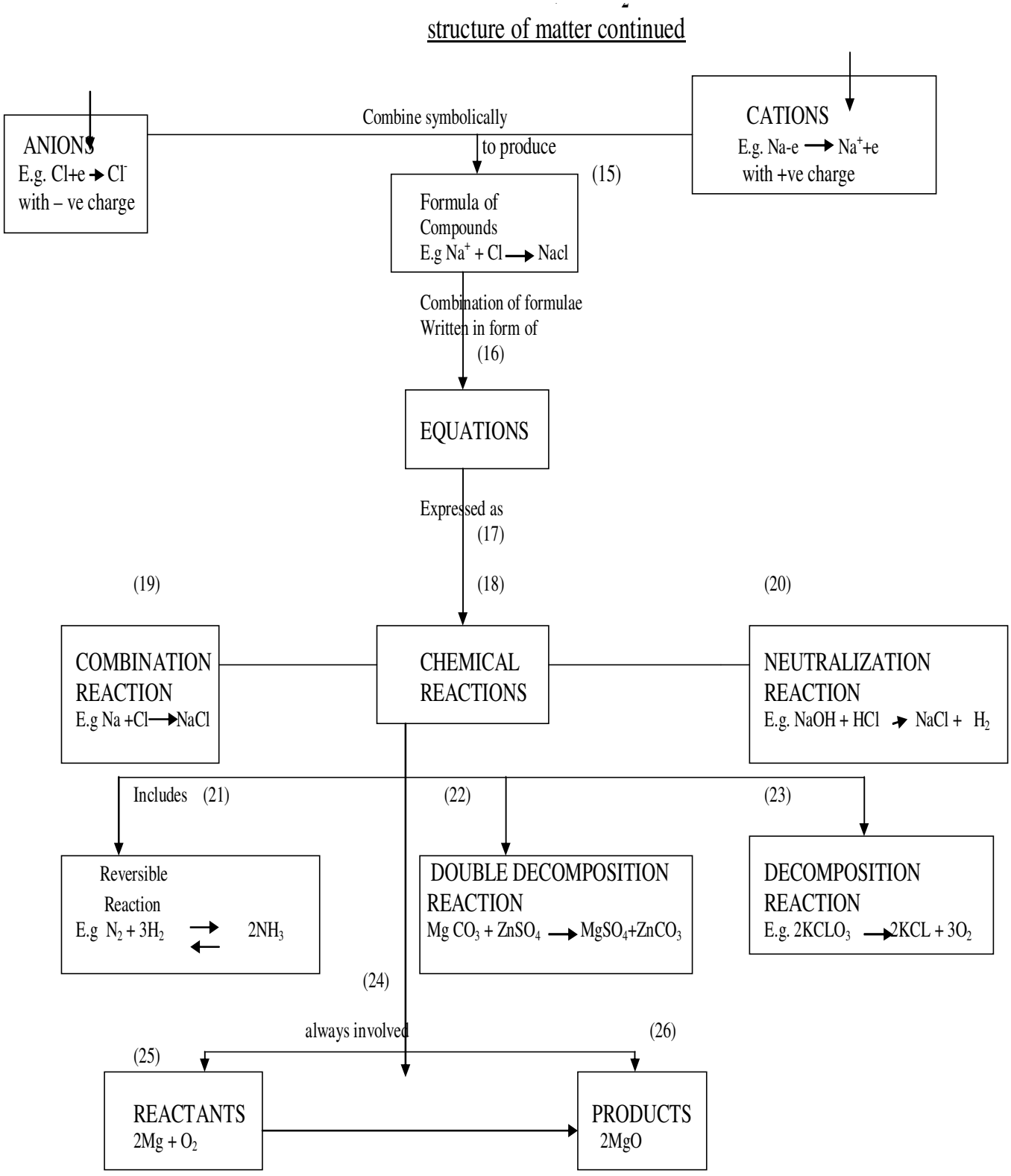
West African Examination Council (WAEC) (2002). Chief examiners reports, Nigeria. 143-146.

White R, Gunstone R (2006). Probing understanding. New York: Falmer Press.

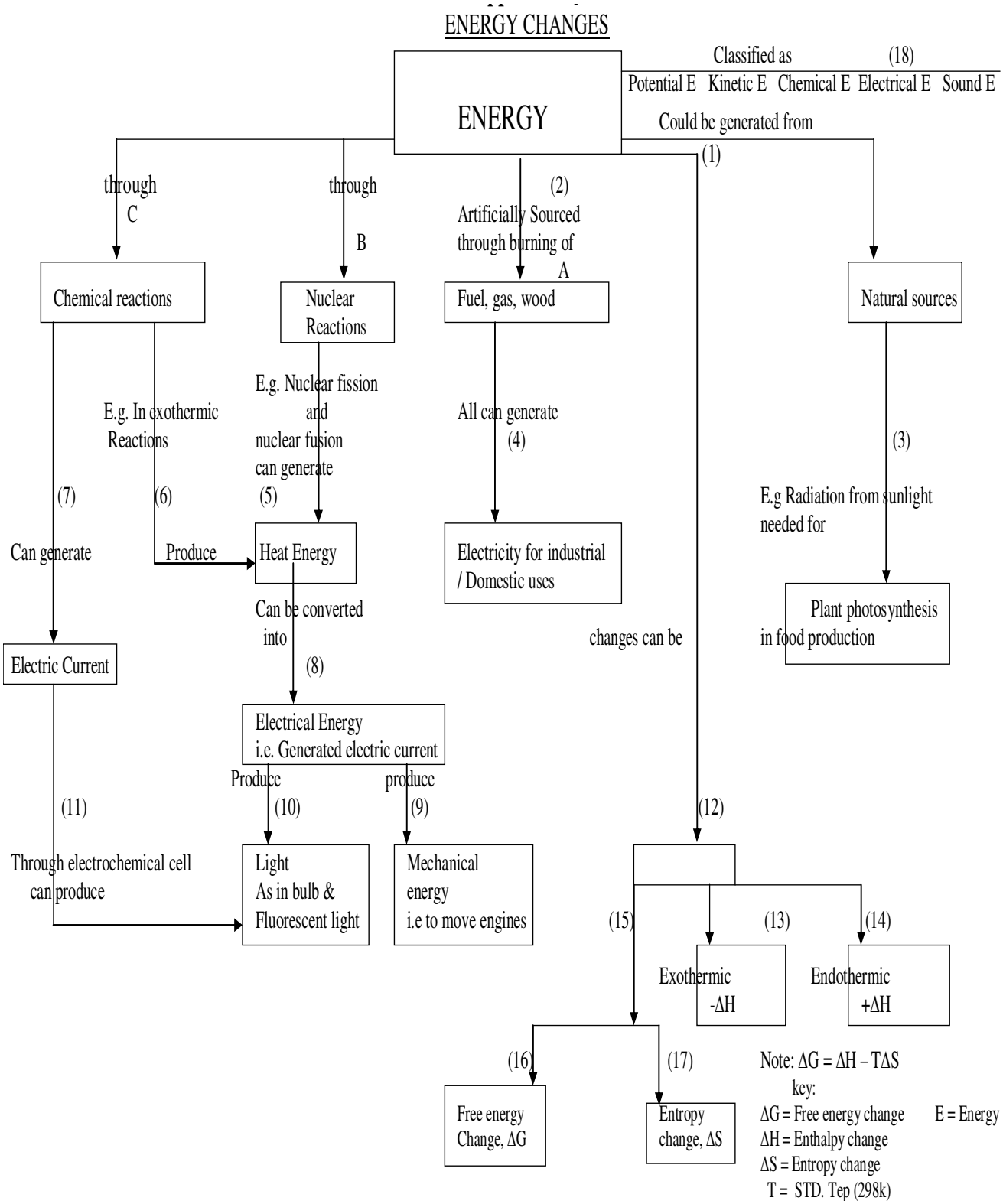
Appendix A_1


STRUCTURE OF MATTER
ATOM
(1)
(2)
(3)
Consists of
consists of
Consists of
Make up
PROTONS
+ve particles
NEUTRONS
ELECTRONS
-ve particles
Are contained in
(4) Neutral particles
are contained in
(6)
Are contained in
(7)
(5)
ELEMENTS
May be
(8)
(10)
(9)
NON-METALS
E.g O_2, Cl_2, H_2, etc
combine with
METALS
eg Na, Al, Ca, etc
to form
(11)
Gain electrons
to become
combine with other
non-metals to form
COMPOUNDS
E.g. Cao, Kcl, etc
Lose electrons to
form.
(14)
(12)
(13

Appendix A_2


structure of matter continued
ANIONS
E.g. Cl+e → Cl⁻
with – ve charge
Combine symbolically
to produce
(15)
CATIONS
E.g. Na-e → Na⁺+e
with +ve charge
Formula of Compounds
E.g Na⁺ + Cl → Nacl
Combination of formulae Written in form of
(16)
EQUATIONS
Expressed as
(17)
(19)
(18)
(20)
COMBINATION REACTION
E.g Na +Cl → NaCl
CHEMICAL REACTIONS
NEUTRALIZATION REACTION
E.g. NaOH + HCl → NaCl + H2
Includes (21)
(22)
(23)
Reversible Reaction
E.g N2 + 3H2 ⇌ 2NH3
DOUBLE DECOMPOSITION REACTION
Mg CO3 + ZnSO4 → MgSO4+ZnCO3
DECOMPOSITION REACTION
E.g. 2KCLO3 → 2KCL + 3O2
(24)
always involved
(25)
(26)
REACTANTS
2Mg + O2
PRODUCTS
2MgO

Appendix A_3


ENERGY CHANGES
ENERGY
Classified as (18)
Potential E Kinetic E Chemical E Electrical E Sound E
Could be generated from
(1)
through C
through B
(2)
Artificially Sourced through burning of A
Chemical reactions
Nuclear Reactions
Fuel, gas, wood
Natural sources
E.g. In exothermic Reactions
E.g. Nuclear fission and nuclear fusion can generate
All can generate
(4)
(3)
(7)
(6)
(5)
E.g Radiation from sunlight needed for
Can generate
Produce
Heat Energy
Electricity for industrial / Domestic uses
130
Can be converted into
(8)
changes can be
Plant photosynthesis in food production
Electric Current
Electrical Energy i.e. Generated electric current
Produce
produce
(11)
(10)
(9)
(12)
Through electrochemical cell can produce
Light As in bulb & Fluorescent light
Mechanical energy i.e to move engines
(15)
(13)
(14)
Exothermic -ΔH
Endothermic +ΔH
(16)
(17)
Free energy Change, ΔG
Entropy change, ΔS
Note: ΔG = ΔH – TΔS
key:
ΔG = Free energy change
ΔH = Enthalpy change
ΔS = Entropy change
T = STD. Tep (298k)
E = Energy