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Effect of experiential concept mapping teaching strategy on students' academic achievement in chemistry in Tigania West sub county, Kenya

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Abstract
Students require adequate exposure to chemistry to enhance achievement in the subject. Academic attainment in chemistry in Kenya Certificate of Secondary education (KCSE) has been relatively low in the years 2013 to 2019. The aim of this study was to look into the influence of Experiential Concept Mapping teaching strategy on achievement of students in Chemistry in Tigania West Sub-County. A true -experimental research design and in particular, the Solomon Four non- corresponding regulator cluster design was utilized. It involved a target population of 1765 Form two learners from Tigania West Sub County. The sample size comprised 182 students from four sub county coeducational secondary schools, selected using simple random sampling. Simple random sampling technique was employed to allot the schools to either investigational or regulator clusters. The study comprised four clusters; two investigational clusters (E1 and E2), and two regulator clusters (C1 and C2). A Chemistry Achievement Test (CAT) was administered during the pre-test and post-test in order to look into learners' attainment in chemistry. Data obtained was analyzed by use of Statistical Package for Social Science (SPSS) version 24. For descriptive statistics, percentages, frequency distributions, mean and standard deviation was used. ANOVA, t-tests, U-test, and H-test were used for inferential statistics. The statistical significance was tested at $\alpha = 0.05$. The results revealed that there was a statistically significant difference in achievement in learning chemistry among the control and experimental clusters of students. Gender of students' had no significant effect on achievement when they are taught using Experiential Concept Mapping teaching method. Adoption of ECM is recommended as appropriate for instructional of chemistry in secondary schools. These study findings will provide valuable reference for teachers, educational stakeholders and curriculum developers, policy makers in education, researchers and academicians.

Keywords: academic, achievement, curriculum, chemistry, student, Tigania

1. Introductions
Science skills provides a significant aspect to mankind, its utilization in pharmaceuticals and chemical engineering has aided in realizing the need of medication and regulation of diverse pathogens [15]. Nations at the forefront of modern development are those that have invested resources in the establishment of well-supported science and technology education [11]. Science and technology are most needed in this modern era because they are parameters for classifying nations as developed or developing.

Emphasis should be laid on chemistry education in Secondary Schools particularly in reference to the instructional process. Since it aids in the unification of other science disciplines [3]. Howbeit, the dismal attainment in Chemistry by most learners is of great concern in Secondary Schools [12] attributed the failure of students to the difficulties with questions requiring description of experimental procedure, explanations and tasks that require practical experience.

Low achievement in Chemistry is a is a clear indication that learners possess challenges in acquisition of skills in this discipline besides utilization of the acquired knowhow during examinations [5]. According to [4] a teacher's success in the classroom is pegged on the use of appropriate and effective teaching methods. The teaching of Chemistry requires a range of new strategies to facilitate communication in teaching and learning and to enhance students' ability to grasp knowledge which occurs when a teaching method takes control of students learning experience. Students' academic achievement is determined by the quality of teaching and learning approach learners have been exposed to [1]. Experiential concept mapping approach is a type of learning approach that centres on learners.

Experiential learning denotes the learning and also progress that attained through individually single-minded practice and participation. Teachings in empirical learning are organized so that each learner contributes wholly in the learning activity and exhibits mechanism on its environment and course [13]. Concept Mapping is a graphical way of representing and structuring knowledge by use of a concept map [10]. A typical concept map represents associations amongst notions, descriptions or verses, just like a sentence illustration denotes its syntax, a road map shows location of thoroughfares and townships, and a trail diagram denotes the workings of electrical gadgets [8]. In each model map, ideas and information in circles and boxes get linked using branded barbs, in a descending forking classified configuration. The relationships between ideas are articulated using networking expressions on top of the arrows, also in a descending-branching and categorized configuration [8].

Conception maps have proven to be effective for stimulating generation of ideas, aiding creative thought, brainstorming and communicating complex ideas [10]. Concept maps are mostly drawn using paper and pencil, but with recent advances in technology, there are computer programmes that can also be used to do this. When the latter is done, it is referred to as Software-Oriented Concept Mapping" Experiential Concept Mapping (ECM) instructional approach is a combination of empirical learning together with notion mapping instructional techniques. This technique provides an opportunity to learners to directly participate in creating experiential thought maps as a learning undertaking. ECM is intended to aid learners improve in the acquisition of science skills through promotion of significant learning [7]. Thus, ECM helps prevent memorization, which is very common in Kenya's education system and also promotes meaningful learning.

2. Materials and Methods

2.1 Location of the Study Area

The research study was undertaken in Tigania West sub county, Meru County. The Sub County has students with various academic abilities and different social economic background. In addition, Tigania West sub-county has steadily recorded dismal achievement in KCSE science subjects, chemistry inclusive, yet there is no empirical research carried out in the sub county to help education stakeholders understand the reasons behind the low achievement in chemistry thus the need for the study.

2.2 Target Population

The study targeted all public secondary schools in Tigania West Sub County. There was an approximate student population which constituted of 1765 Form two students in Tigania West Sub County as shown in Table 1. Form two learners were targeted to participate in this study since the main topic; the structure of the atom and the periodic table at this level.

Table 1: Target Population

School type	Number of schools	Total number of students
Girls only	4	365
Boys only	3	400
Co-educational schools	20	1000
Total	27	1765

Source: Tigania West Sub County Education Office (2021)

Information on Table 1 indicates that there were 4 girls' boarding schools in Tigania West sub- county with 365 form two students, 3 boys' boarding schools with 400 form two students and 20 co-educational schools with 1000 Form two learners. The study targeted 1765 Form two learners in Tigania West sub-county.

2.3 Sample Size and Sampling Procedures

Simple random sampling method was employed in the selection 4 sub county co-educational secondary schools in Tigania West Sub County. The sampled schools were further assigned as either control group or experimental group using simple random sampling (Table 2).

Table 2: Sample Size

School type	Sample school	Total population	Number of Students		
			Experiment Group	Control Group	Total
Sub county coeducational school	4	40	50	40	90
		48			
		50	44	48	92
		44			
Total		182	94	88	182

Table 2 demonstrates that learners in sampled coeducational schools were 40, 48, 50 and 44, totaling to 182 form two students. The schools assigned as experimental groups had 50 and 44 students, while those assigned as the control groups had 40 and 48 students. In cases where a school had more than one stream, all of them were involved in this investigation.

2.4 Research Instrument

The Chemistry achievement tests **(**CAT) was utilized in assessment learner's mastery of subject matter and also to quantity learner accomplishment in chemistry in the main area of structure of the atom and the periodic table. The test consisted of items from the same topic that would be covered in the course of the investigation. The subject matter of the test included; the atom, the periodic table, isotopes, ion formation and the periodic table. The CAT consisted of 10 items with short answer queries and designed queries on the topic covered. The items verified knowhow, understanding, and use of the acquired content with an aggregate score of 30 marks. The test constituted a pre-test to the investigational cluster (E1) and regulator cluster (C1), prior to the commencement of the course and to all clusters at the end of the research period as a post test. The items were ranked with the aid of a homogenous marking scheme and the realized tallies were documented for scrutiny.

2.5 Data Collection

The researcher visited the sampled schools to establish a conducive working environment with the school management besides getting introduced to the chemistry instructors. The investigator then trained teachers of the investigational cluster on how to use ECM for four days. CAT (pre-test) was administered to experiential cluster (E1) and regulator group (C1) followed by three weeks' integration of ECM approach to the investigational clusters E1 and E2. The conventional teaching strategy was subjected to regulator clusters (C1 & C2). A post-test CAT and SMQ were then administered to all the regulator and investigational clusters. Data was collected by use of

Chemistry Achievement Test (CAT) and coding of collected data for analysis.

2.6 Data Analysis
The information gathered was counted, coded and prepared for analysis. Descriptive statistics (mean and standard Deviation) and inferential statistics (Kruskal-Wallis H test, Mann-Whitney U -test, ANOVA and t-test) were employed in the analysis the gathered data. This was achieved by the use of the Statistical Package for Social Sciences (SPSS) version 24. The information was then presented in tables, and bar graphs.

3. Results
3.1 Respondents' Demographic Information
Analysis of respondents' demographic information was done. This included gender of the students (Table 3).

Table 3: Gender of the Respondents.

	Control groups		Experimental groups		Total	
Gender	**f**	**%**	**F**	**%**	**F**	**%**
Male	39	44.32	50	53.19	89	48.90
Female	49	55.68	44	46.81	93	51.10
Total	88	100	94	100	182	100

Results on Table 3 indicates that 55.68% of the respondents under control group were female, and 44.32% of the respondents were of the male gender while, 53.19% of the respondents on experimental group were of the male gender while 46.81% of the respondents comprised of the females. This implies that more girls than boys were in the control groups. .Experimental groups had 50 boys and 44 girls and that the overall percentage of girls involved in the study was 51.10% and that of boys was 48.9%. Information in Table 4 shows the groups involved in the study and number of students in each groups.

Table 4: Sample Size Stratification

Group	Experimental and control	Number of students
C1	Control	40
C2	Control	48
E1	Experiment	50
E2	Experiment	44
Total		182

Information on Table 8 indicates that control group (C1) had 40 students, control group (C2) had 48. Experimental Group (E1) had 50 students and experimental group (E2) had 44 students.

3.2 Pre-test Results
A pre-test on Chemistry Achievement Test (CAT) was administered to regulator cluster (C1) and investigational cluster (E1). Administration of CAT was to ensure the groups used in the study were homogeneous before administration of the ECM teaching strategy. The CAT was marked out of 30. Table 5 indicates t-test results of pre test tallies on CAT.

Table 5: t-test Results of Pre-test Scores on CAT

Group	N	Mean	SD	SE	Df	t-value	p-value
C1	40	6.03	4.154	0.657	90	0.284	0.777
E1	52	5.77	4.368	0.606			

Significance level= 0.05

The findings on Table 5 indicate that the pre-test average for learners in regulator cluster (C1) had a higher mean score (M=6.03, SD = 4.154) than that of students in investigational cluster (E1) (M=5.77, SD=4.368). To test for homogeneity of the groups, t-test was conducted in order to determine if there was statistically significant difference in pre-test means scores. The results t (90) =0.284, p=0.777 shows that the two groups had no statistical significant differences and therefore had similar characteristics before the ECM teaching strategy was administered. Therefore, the clusters were considerably appropriate for this investigational study. Table 6 indicates t- test results of pre test tallies on CAT centered on gender.

Table 6: T-test Results of Pre-test Scores on CAT based on Gender

Group	N	Mean	SD	SE	Df	t-value	p-value
Male	46	5.54	4.569	0.674	90	-0.758	0.451
Female	46	6.22	3.938	0.581			

Significance level=0.05

From Table 6, the pre-tests mean score for male learners was 5.54 while for the female learners was 6.22. This indicates scores for female students were higher. T-test was conducted in order to establish if there existed a statistically significant difference in pre-test means scores based on gender. The t-test values were t (90) = -0.758, p=0.451. Thus, indicates that there was no significant mean difference in both male and female students and therefore had similar characteristics before the administration of ECM teaching strategy. Therefore, students' achievement in chemistry was comparable in both gender (male and female).

3.3 Effect of Experiential Concept Mapping Instructional Approach on Students' Academic Achievement in Chemistry
The post-test mean scores on CAT were analyzed to compute the effect of Experiential Concept Mapping instructional technique on learners' academic achievement. Results from the tests carried out were used to establish and compare whether the scores on CAT for students taught using ECM had a significant difference with those taught using conventional teaching methods. Table 7 indicates the average tallies and standard deviations of the regulator and investigational clusters.

Table 7: CAT Post-test Score by Four Groups

Group	N	Mean	SD
C1	40	8.15	5.265
C2	48	8.63	5.433
E1	50	17.96	4.886
E2	44	9.82	6.525
Total	182	11.3736	6.8619

Table 7 presents the results for post-test scores by groups. The control groups C1 and C2 had a CAT mean of 8.15 and 8.63 respectively. Conversely, investigational clusters E1 and E2 had a mean score of 17.96 and 9.82 respectively. The results indicated that, investigational clusters (E1 and E2) were found to have greater average tallies than the controller clusters (C1 and C2). Investigational clusters (E1 and E2) were instructed by use of ECM instructional approach while regulator clusters (C1 and C2) were instructed through conservative teaching methods**.** This is an

indication from the results that learning chemistry using ECM strategy recorded a positive effect on the learners' academic attainment and therefore showed that ECM teaching strategy prove better than the conventional teaching methods. Figure 1 gives a graphical comparison of the four groups in post-test mean score on CAT.

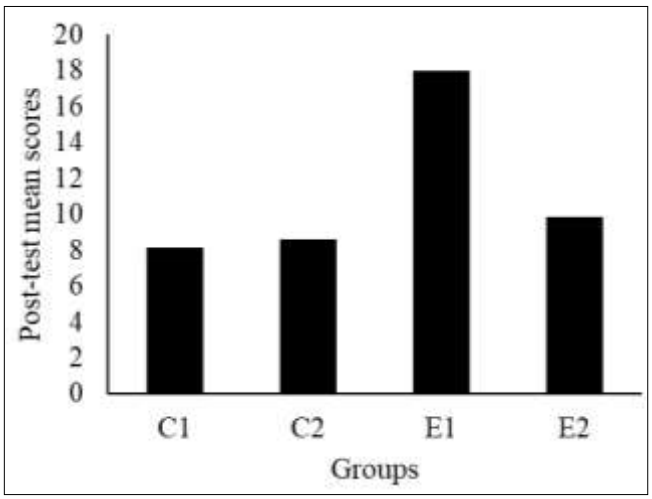

Fig 1: Post-test Mean Score for Students

The information on Figure 1 showed that the use of ECM teaching strategy improved the students' achievement in comparison with conservative instructional techniques. Groups E1 and E2 that were taught using ECM teaching strategy had higher post- test mean scores against groups C1 and C2 learners instructed by aid of conservative instructional methods. In order to establish whether there were any significant differences in the means among four groups, The Analysis of Variances (ANOVA) was conducted and the results were as illustrated in Table 8.

Table 8: The ANOVA test Results for the Post Tests Scores on CAT

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3053.778	3	1017.926	33.132	.000
Within Groups	5468.815	178	30.724		
Total	8522.593	181			

Significance level= 0.05

The ANOVA test results showed that a statistically significant mean difference in post-test tallies between the different groups of learners, ($F_{3, 178}$ = 33.132, p < 0.001) occurred. Since the ANOVA test results indicated that there were statistically significant differences between the means of post-tests for the four groups, the null hypothesis one (H_{01}) is rejected, which states that there is no statistical significant difference on learner academic achievement in chemistry when instructed by aid of Experiential Concept Mapping instructional technique in Tigania West Sub County. The outcome therefore, confirmed that concept-mapping strategies are learner-centered and capable of making remarkable impact on students' achievement. The use of Experiential Mapping Teaching approach gives a student an opportunity to understand concepts and be able to develop abilities and skills in solving chemistry problems. This was possible because learners were directly engaged in the learning practise hence are able to discover some ideas on their own through task centered teaching approach including discovery method, problem-solving and concept mapping teaching method, learning is better facilitated. A post hoc was done using Turkey HSD pairwise comparisons to determine specific differences. The outcomes are as presented in Table 9.

Table 9: The Turkey HSD Pairwise Comparison of the Post-Test Scores on CAT for Four Groups

(I) groups for post tests	(J) groups for post tests	Mean Difference (I-J)	Std. Error	Sig.
C1	C2	-.475	1.187	.978
	E1	-9.810*	1.176	.000
	E2	-1.668	1.211	.515
C2	C1	.475	1.187	.978
	E1	-9.335*	1.120	.000
	E2	-1.193	1.157	.731
E1	C1	9.810*	1.176	.000
	C2	9.335*	1.120	.000
	E2	8.142*	1.146	.000
E2	C1	1.668	1.211	.515
	C2	1.193	1.157	.731
	E1	-8.142*	1.146	.000

Significance level=0.05

Results in Table 9 shows that specific significant difference between groups was shown by the Turkey HSD pairwise comparison results. When C1-E1 (0.000), C2-E1 (0.000), E1-E2 (0.000), and E2-E1 (0.000) were compared, the difference was found to be statistically significant. On the other hand, when C1-C2 (0.978), C1-E2 (0.515), and C2-E2 (0.731) were compared, the differences were found to be statistically insignificant. The findings indicate that ECM teaching strategy enhance the students' academic achievement in chemistry in comparison with conservative instructional methods.

4. Discussion

The use of Experiential Concept Mapping approach gives a student an opportunity to understand concepts and be able to develop abilities in solving a given assignment. The findings of the current study concur with the findings of a research by [2]. Their study was on the influence of Experiential Learning Approach (ELA) on learner's mathematical creativity among secondary school learners of Kericho East sub county- Kenya. The outcome of the Post Test Mean tallies on Mathematical Creativity Test (MCT) for the four clusters were significantly varied. Cluster E1 and E2 had averages of 35.53 and 32.79 respectively while cluster C1 and C2 possessed averages of 25.83 and 24.98 respectively. ANOVA outcome revealed that the difference in the average tallies among the four clusters were significant. These outcomes therefore demonstrated that ELA has a positive influence on learners' Mathematical Creativity. ELA instructional approach generated a significant effect on mathematical creativity among secondary school learners.

[16] carried out a study in Experiential Cooperative Concept Mapping Approach (ECCMA) among secondary school students of Nyeri county, Kenya and found that achievement in physics improved as evident by statistically significant difference between the averages of learners who were instructed by use of ECCMA and those through RTM. Using ECM in instructional of science disciplines taught is crucial since it aids the learners to relate the tenets, acquired know-how and skills to build suitable scientific expedients from available means. It is therefore significant and prudent to initiate learner centered techniques, like ECM teaching

method that will in the long run enhance achievement of learners in chemistry.

These research findings are consistent with those of [17] on influence of concept mapping based instruction on learners' achievement in physics among secondary schools in Nairobi county, Kenya The study revealed that the average gain tallies of the respondents in the investigational cluster taught using instructional concept maps (ICM) were significantly greater than those who were taught using conservative instructional techniques (CIT).

The results from this investigational study established the average gain difference among the investigational and the regulator cluster was statistically significant. The findings are in agreement with findings from a study on probing influence of Concept Mapping Instruction Approach on learners' achievement in basic science in Nakuru county, Kenya by [14]. Study findings revealed that concept mapping had a positive influence on the learners' achievement in basic science than conservative method. The treatment cluster was instructed on elementary science by use of concept mapping technique whereas the other was instructed by aid of conservative method. According to [9], the use of experiential concept mapping and instructional strategy promotes the learners' achievement and assertiveness in learning physics. [9] carried out a study on efficacy of Experiential Concept Mapping instructional technique on attainment and assertiveness in physics by secondary school learners in Maara sub county, Kenya. The rfindings revealed that after exposure to concept mapping, majority of the students moved to high achievement level as compared to before treatment using concept mapping. Therefore, a clear indication of effective enhancement on students' achievement in physics when concept mapping was used. The indication was evident by statistically significant difference among learners' accomplishment when subjected to experiential concept mapping instructional method and learners taught by use of conservative teaching methods.

The findings of the current investigational study were consistent with a study carried out by [6], on the influence of software –based concept mapping on Kenyan secondary school learners in Kakamega county in electrochemistry. On the basis of data collected in the study made a conclusion that utilization of concept mapping software to teach the abstract form four topic of electrochemistry significantly improves students' achievement in the topic when compared to the use conventional instructional approaches. The positive effect of concept mapping was attributed to the fact that it was a hands-on experience for all the learners, who were all able to visualize all abstract concepts in the topic.

5. Conclusion

The findings indicated that learners who were instructed chemistry by utilization ECM had greater tallies in the CAT compared to those instructed using conservative teaching methods. Therefore, this strategy serves to complement the conventional instructional methods due to its ability to generate greater academic attainment when compared to the utilization of conventional methods alone.

6. Recommendations

Experiential Concept Mapping has drawn nearly equal benefits in terms of students' achievement, thus the teaching strategy should be incorporated and adopted to supplement other teaching strategies that have shown positive impacts on students' achievement to further improve the performance in KCSE.

7 Acknowledgement

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Appendices

Appendix A: Chemistry Assessment Test (CAT)

1) Define an atom. (1mk)
2) Atoms are said to be electrically neutral. Explain. (2mks)
3) Distinguish between atomic number and mass number. (2 mk)
4) What are isotopes? (1mk)
5) An isotope Q has 18 neutrons and a mass number of 34.
   a) Draw the atomic structure of Q (2mks)
   b) write the electron arrangement of Q (1mk)
   c) How does Q form its ion? Explain. (1 mks)
   d) Lithium has two isotopes; $^{7}_{3}$Li and $^{6}_{3}$Li.
   i) Determine the number of neutrons in $^{6}_{3}$Li.(2mks)
   ii) If the relative atomic mass of lithium is 6.94. Which of the two isotopes is the most abundant? Give a reason. (2mks)
6) a.) What is meant by a compound? (1 mks)
   b.) List the atoms present in each of the following compounds:
   i) Zinc chloride (1mk)
   ii) Calcium carbonate (1mk)
7) An element Y forms an ion Y^{2+} with the electron arrangement 2.8.
   a) Write the electron arrangement of element Y. (1 mk)
   b) To which group and period does element Y belong? (1 mks)
   c) Draw a dot (.) or cross diagram to represent electrons of element Y.(2mks).
8) The following table gives a summary of some properties of elements P,Q, R, S. the letters do not represent the actual symbols of elements.

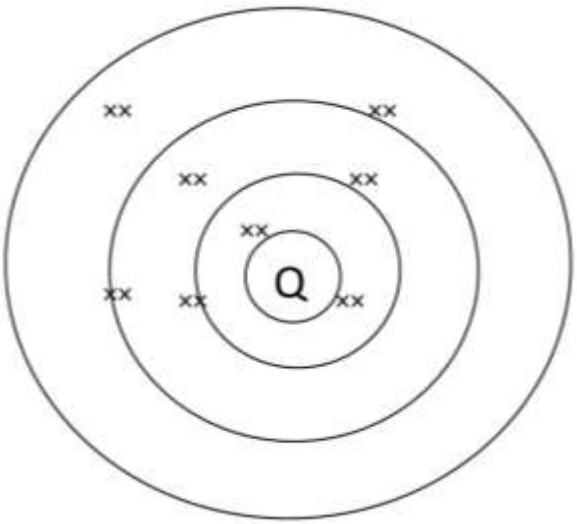
Element	Electron configuration	Valency
P	2.2	2
Q	2.7	1
R	2.8.3	3
S	2.8.8.2	1

a) Which two elements have similar chemical properties? Explain. (2mks)
b) Write the formula of a carbonate of S.(1 mk)
c) Identify the element which is a non-metal. (1mk)
9) Write balanced equations for the following reactions.
   i) The reaction of magnesium with water. (1mks)
   ii) The reaction of Sulphur with oxygen. (1mks)

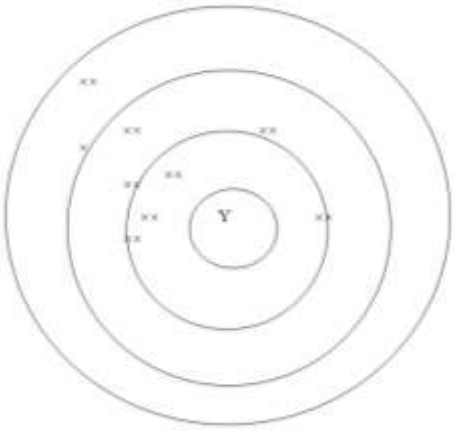
10) An element X consist of three isotopes with mass numbers of 22, 24, and 25 with percentage abundance of 89.6%, 6.4% and 4.0% respectively. Find the relative atomic mass of element X. (3 mks).

Appendix B: C.A.T. Marking Scheme

1) An atom is the smallest particle of an element, which can take part in a chemical change. (1mk)
2) An atom contains an equal number of protons and neutrons. (1mk). The positively charged protons and negatively charged electrons in an atom have a net charge zero. (1mk)
3) Atomic number is the number of protons in an atom (1mk) while mass number is the sum of protons and neutron in an atom. (1 mk)
4) Isotopes are atoms of the same element (1/2mk) that have the same number of protons but have different number of neurons, hence the difference in their mass numbers. (1/2 mk)
5) 3 energy levels (1mk) Correct distribution of electrons (1 mk)



(a) 2.8.6 (1mk)
(b) Element Q forms its ion by gaining two electrons in its outermost energy level (1mk). Q requires less energy to gain two electrons than it would use to lose six electrons. (1mk)
(c) (i) mass number – atomic number = no. of neutrons
6 - 3 = 3 neutrons Method (1mk), answer (1mk)
ii) The most abundant isotope is $^{7}_{3}$ Li. (1mk) Its mass number is closer to the relative atomic mass. (1 mk)
6) a) A compound is a pure substance made of two or more elements that are chemically combined. (1mk)
b) i) Zinc (1/2 mk)and Chlorine(1/2mk)
ii) Calcium (1mk), carbon and oxygen (1 mk)
7) a) 2.8.2 (1 mk)
b) Group 2(1mk), period 3 (1mk)
c) 3 energy levels (1mk), correct distribution of electrons (1mk)



8) a) Element P and element S. (1mk) they have two electrons in the outermost energy level, thus they are in group II. Elements in the same group exhibit similar chemical properties. (1mk)
b) SCO_3 (1mk)
c) element Q (1mk)

9) i) $Mg_{(s)} + 2H_2O_{(l)} \longrightarrow Mg(OH)_{2\,(aq)} + H_{2(g)}$

ii) $S_{(s)} + O_{2\,(g)} \longrightarrow SO_{2(g)}$

Correct chemical formulae (1/2mk), balanced equation (1/2 mk) for each equation.

10) 22 × 89.6/100 + 24 × 6.4/100 +25 × 4.0/100 (method 1mk)
= 1971.2/100 +153.6/100 + 100/100 (method 1mk)
=2224.8/100
=22.248 (answer 1mk)