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Influence of Science Process Skills Teaching Approach on Secondary School Students' Achievement in Chemistry Practical in Kisii South Sub County, Kenya

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Abstract:
This study focused on the influence of Science Process Skills Teaching Approach (SPSTA) on secondary school students' achievement in Chemistry Practical. The science process skills which were selected for the study include experimenting, observation and classification. The objectives of this study were: To determine whether the achievement of students who are taught using SPSTA is statistically different from that of students who are taught using the RT methods in chemistry practical and to compare the achievement of the boys and the girls taught using SPSTA in Chemistry practical. The study employed quasi- experimental, Solomon Four non-equivalent control group pretest-posttest design. A sample of 366 students in the four schools was selected. SPSTA was used to teach the experimental group while the control group was taught using the regular teaching (RT) methods. All groups were taught the chemistry content on the topic 'Salts' which is part of the Form Two Chemistry syllabus. A Chemistry Practical Test (CPT) was used for data collection. Data was analyzed using one-way ANOVA, ANCOVA and t-test. Hypotheses were tested at a significance level of coefficient alpha (α) value of .05. Results of the study show that there was a statistically significant difference between the achievement means of students who were taught through SPSTA and those taught through RT methods in Chemistry practical. The researcher concludes that SPSTA facilitates students' achievement in Chemistry practical. The researcher recommends the use of SPSTA in Chemistry teaching in order to improve the students' achievement in Chemistry practical.

Keywords: *Science process skills teaching approach, student's achievement, chemistry practical*

1. Introduction

In Kenya, Chemistry Education at secondary school level is aimed at preparing learners to deal with the contemporary environmental challenges in society. It also prepares learners for careers such as engineering, medicine, body therapy, education, pharmacy and food technology. The secondary school Chemistry objectives as outlined by Kenya Institute of Education (2002) include among others to: - select and handle appropriate apparatus for use in experimental work and to make accurate measurements, observations and draw logical conclusions from experiments. Kenya certificate of Secondary education (KCSE), Kenya National Examinations Council (KNEC) report (2019) shows that Chemistry paper 3, which is the Chemistry practical examination is lowly performed. For instance, the mean mark score in Chemistry paper 3 which is marked out of 40 for the year 2019, 2018 and 2017 was 13.00, 14.44 and 14.4 respectively. This performance can be addressed by considering the teaching method, since teaching method greatly affects performance. Chemistry teaching methods emphasize practical or investigative learning; however, they do not usually offer the learners varied experiences and necessary exposure for an appropriate balance in the development of cognitive ability, psychomotor skills and affective behaviors according to the Kenya Institute of Education (2002). According to Leijen, Valtana and Pedaste (2012), the learning opportunities provided in science lessons are inadequate for effective learning of science as envisaged within the constructivist framework and the nature and quality of teacher-pupil interaction in science lessons also fail to actively promote the acquisition of science concepts. They further argue that the quality of teacher - pupil interaction in the science lessons, does not encourage active and meaningful learning to take place. The Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) report 2015 emphasizes the use of activity, student experiment and improvisation- plan, do, see and improve (ASEI-PDSI) principles in teaching and learning of mathematics and science to enhance the learning process through well planned lesson activities. Science process skills teaching approach is consistent with the principles of ASEI-PDSI. When learners are given an opportunity to learn the content in the school curriculum

through science process skills teaching approach, their ability to develop a variety of skills such as questioning, predicting, observing, manipulating, inferring and critical thinking are enhanced. According to Thomas (2014), the use of science process skills teaching approach enhances the development of skills which enables students to solve problems, think critically, make decisions, find answers and satisfy their concerns and problem solving is the essence of scientific investigations. Studies have shown that Science process skills teaching approach positively influences the learner's achievement in science subjects (Nyakan, 2008; Abungu, 2014). However, its influence in the achievement in Chemistry practical has not been explored. This study was based on experimental approach to teaching which incorporated science process skills of observing, classifying and experimenting; this approach to teaching was referred to as science process skills teaching approach (SPSTA) and it was used to establish its influence on secondary school students' achievement in chemistry practical. The findings of the study show that SPSTA helped to improve the achievement of secondary school students in chemistry practical.

1.1. Objectives of the Study

The study was guided by the following objectives: -

- To determine whether the achievement of students who are taught using SPSTA is statistically significantly different from that of students who are taught using the RT methods in Chemistry practical
- To find out whether there is a statistically significant difference in the achievement of the boys and the girls taught using SPSTA in Chemistry practical

1.2. Hypotheses for the Study

- $H_0$1: There is no statistically significant difference in the achievement of students exposed to SPSTA and those who are exposed to RT methods in Chemistry practical test
- $H_0$2: There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry practical test

1.3. Conceptual Framework for the Study

Figure 1 shows the relationship of variables for determining the influence of SPSTA on secondary school students' achievement in chemistry practical.

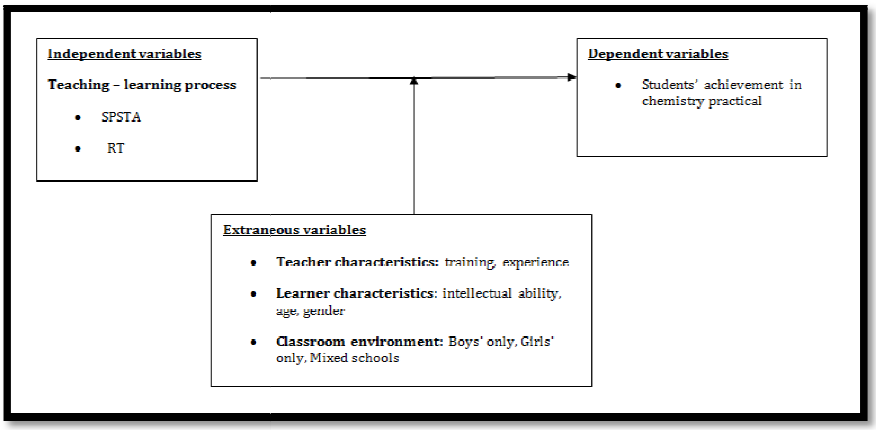

Figure 1: Conceptual Framework for the Study

1.4. Research Design

This study employed quasi-experimental research design in which Solomon four non-equivalent control group design was used. The study used four intact classes from four different schools. Each class represented a group for the study as illustrated in figure 2

Group 1	O_1	X	O_2	experimental group
Group 2	O_1	------	O_2	control group
Group 3	-----	X	O_2	experimental group
Group 4	------	------	O_2	control group

Figure 2: The Research Design
Source: Wiersmaand Jurs(2005)
Key: -Pre-Tests O_1, Post-Tests O_2, Treatment X

--------- Dashed lines show that the experimental and control groups were not equated by randomization hence nonequivalent

1.5. Sampling Procedure and Sample Size

Selection of the sample for the study was done through purposive and random sampling methods. The study used intact classes. A total of eight classes were used for the study. Each school sampled for the study formed a group for the study as follows:

Group 1-the true experimental group (N=92)
Group 2-the true control group (N=90)
Group 3- the experimental extension group (N=88)
Group 4- the control extension group (N=96)

The sample size of the study population was 366 students. These numbers were adequate for the study since Fraenkel and Wallen (2000) recommend at least 40 subjects per treatment group.

1.6. Instrumentation

Chemistry Practical Test (CPT) was used to investigate the students' achievement in chemistry practical. The CPT consisted of practical items with the objective of testing the ability of learners on the practical examination since Chemistry is also tested on a practical paper during the KNEC examination. The CPT contained two items which tested the learner's ability to follow a given procedure, make the correct observation, draw logical conclusion based on their observation. The CPT further tested the learner's ability to design an investigation and carry out an investigation to answer a given question. This instrument was constructed based on the content taught in the topic 'salts' (Appendix A)

1.7. Reliability of the CPT

Split-half reliability method was used to determine the reliability of the CPT. All items on the CPT that purported to measure the same construct were randomly divided into two sets. The entire instrument was then administered to the sample population for piloting of the instrument. After marking the CPT administered in piloting, the total score for each randomly divided half was calculated. The Pearson product moment correlation coefficient of scores between the two halves was calculated. The reliability of the CPT was 0.836. The CPT was considered reliable since reliability was fixed at $\alpha = \geq 0.7$; a reliability considered large enough to declare an instrument reliable (Fraenkel&Wallen, 2000)

1.8. Data Analysis

The nature of data was quantitative (the marks scored in the instruments by the student). Inferential statistics of t-test, ANOVA and ANCOVA were used.

2. Results and Discussion

2.1. Influence of SPSTA on Students' Achievement in Chemistry Practical

CPT was used to determine the influence of SPSTA on students' achievement in Chemistry practical. The CPT was administered as a pre-test and as a post-test. The pre-test was administered to experimental group 1 and control group 2 the CPT pre-test mean scores and standard deviations are presented on table 1

Pre-test CPT	N	Mean	Std. Deviation
Group 1	92	29.87	6.648
Group 2	90	29.72	6.701

Table 1: Mean and Standard Deviation of Learners' Pre-Test Scores In CPT
Source: Field Data

From table 1, the experimental group 1 attained a higher mean than control group 2 in the pre-test. This necessitated a t-test to be carried out on the CPT Pre-test scores to determine whether the mean differences between group 1 and group 2 in the pre-test scores were statistically significantly different. The results are presented in table 2

variable	Group	Mean	Std. error	t-value	df	p-value
CPT	1	29.87	1.399	0.123	89	.902
	2	29.72	1.400			

Table 2: Independent Samples T-Test for Pre-Test Scores on CPT
Source: Field Data

From table 2, the mean differences are not statistically significantly different (t= 0.123, P=.902> .05. from the analysis of the pre – test of the CPT, there is evidence that the groups did not have a statistically significant difference at the start of the study hence the groups could be compared at the end of the study, since they had comparable characteristics. After the treatment, all the groups were subjected to a CPT as a post-test which was scored by the researcher and the data was keyed and coded for analysis. The means and standard deviations of learners' post -test scores in CPT are presented in table 3

	N	Mean	Std. Deviation	Std. Error
gourp1	92	74.98	3.605	.532
group2	90	60.80	3.202	.477
group3	88	74.45	4.060	.612
group4	96	59.29	3.364	.486
Total	366	67.25	8.194	.606

Table 3: Mean and Standard Deviations of Learners' Post-Test Scores in CPT According to Groups
Source: Field Data

From table 3, experimental group 1 posted the highest mean score in CPT, followed by Experimental group 3. control group2 and control group 4 followed in that order. The overall mean score for the four groups was 67.25. Since the means were different, a one-way ANOVA test was carried out to determine whether the mean differences in CPT were statistically significantly different and the results are presented in table 4

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9943.433	3	3314.478	260.558	.000
Within Groups	2277.004	179	12.721		
Total	12220.437	182			

Table 4: One Way ANOVA Test for Post – Test Scores in CPT According to Groups
Source: field data

From table 4, the mean differences were statistically significantly different (df = 3, 179, F = 260.558, P=.00< .05) Since there was a statistically significant difference in the learners' mean scores in CPT, a post hoc analysis test was performed to determine the groups which were statistically significantly different and the results are presented in table 5

(I) Post-test CPT	(J) Post-test CPT	Mean Difference (I-J)	Std. Error	Sig.
	group3	.524	.752	.898
	group4	15.687*	.736	.000
group2	group1	-14.178*	.748	.000
	group3	-13.655*	.756	.000
	group4	1.508	.740	.178
group3	group1	-.524	.752	.898
	group2	13.655*	.756	.000
	group4	15.163*	.744	.000
group4	group1	-15.687*	.736	.000
	group2	-1.508	.740	.178
	group3	-15.163*	.744	.000

Table 5: Multiple Comparison of Post – Test Scores in CPT by Group
**The Mean Difference Is Significant At 0.05 Levels*
Source: Field Data

From table 5, there was a statistically significant difference in the mean scores of experimental group 1 and that of control group 2 and group 4 (t=14.178, p=.000<.05 and t=15.687, p=.000<.05) respectively. The mean difference between experimental group 3 and that of control group 2 and group 4 was also statistically significantly different (t=13.65,p=.000<.05 and t=15.163, p=.000 <.05) respectively The mean difference between experimental group 1 and experimental group 3 was not statistically significantly different (t= 0.524, p= .898>.05) and mean difference between control group 2 and control group 4 were not statistically significantly different (t=1.5808, p=.178 >.05) since experimental group 1 and 3 had a statistically significantly higher mean than the control group 2 and 4, SPSTA resulted in students performing better in Chemistry practical than the RT methods.

Having established that there was a statistically significant difference in the achievement of students who are taught using SPSTA and that of students taught using regular teaching methods in Chemistry practical, there was need to find out whether the groups were different before the study or the difference was as a result of instruction. To do this the learners' KCPE scores were used as a covariate. Table 6 shows the adjusted post-test CPT mean scores for ANCOVA with KCPE scores as covariate

Group	N	Mean	Std. Deviation
group1	92	64.30	13.715
group2	90	55.78	9.813
group3	88	68.84	16.752
group4	96	51.98	11.950
Total	366	60.23	14.935

Table 6: Adjusted Post -test CPT Mean Scores for ANCOVA with KCPE Scores as Covariate
Source: field data

From table 6, experimental group 3 had the highest mean followed by experimental group1 then control group 2 and control group 4 followed in that order. The ANCOVA of the post- test scores on the CPT are presented in table 7

	Sum of Squares	df	Mean Square	F	p-value
Corrected model	5319.313	3	1729.828	9.528	.000
KCPE	552.668	1	552.668	4.914	.049
Error	27133.714	178	141.201		

Table 7: ANCOVA on the Post -test CPT
Source: Field Data

Table 7 shows there is a statistically significant difference between the means at p< .05. F(3,178) = 9.528, p= .000<.05). The post hoc pair wise comparisons based on the ANCOVA are displayed in table 8

(I)post-test CPT	(J)Post-test CPT	(I-J)	Std. Error	p-value
group1	group2	8.52*	2.492	.034
	group3	-4.54	2.507	1.000
	group4	12.32*	2.452	.001
group2	group1	-8.52*	2.492	.034
	group3	-13.06*	2.519	.001
	group4	3.8	2.466	1.000
group3	group1	4.54	3.307	1.000
	group2	13.06*	3.289	.001
	group4	16.86*	2.481	.000
group4	group1	-12.32*	2.452	.001
	group2	-3.8	2.466	1.000
	group3	-16.86*	2.481	.000
*the mean difference is significant at 0.05 level				

Table 8: Pair Wise Comparisons Based on ANCOVA
Source: Field Data

From table 8, there is a statistically significant difference between experimental group 1 and control group 2 and 4 (t= 8.52, p=.034<.05 and t=12.32, p= .001<.05) respectively. There is also a statistically significant difference between experimental group 3 and control group 2 and 4 (t= 13.06, p=.001<.05 and t=16.86, p=.000<.05) respectively. The mean differences between experimental group 1 and experimental group 3 were not statistically significant (t=4.54, p=1.000>.05) and the mean differences between control group 2 and control group 4 were also not statistically significant (t=3.8, p=1.00>.05)

3. Discussion of Results on Influence of SPSTA on Students' Achievement in Chemistry Practical

Objective 1 which sought to find out whether there is a statistically significant difference in the achievement of students who are taught through SPSTA and that of students who are taught using the regular teaching (RT) methods in Chemistry Practical found that there was a statistically significant difference in the achievement of students who are taught through SPSTA and that of students who are taught using RT methods in Chemistry Practical with the students taught using SPSTA posting higher achievement scores in CPT post-test than the students who were taught using RT methods hence HO1 which stated that: There is no statistically significant difference between the achievement of students who are taught using SPSTA and those who are taught using RT methods in Chemistry Practical were rejected. Findings of this study are in line with Akpa (2002) who argues that giving a student an opportunity in identifying the main objectives of the work and in planning and executing it identifying the conceptual and practical difficulties encountered and also allowing the student to suggest practical alterations and improvements could result in a significant positive impact on student's ability to learn both the desired practical skill and the underlying theory.

Teachers should ensure that learners experience the basic and integrated process skills of science (Abrahams & Millar, 2008). Further, Watts (2013) argue that when learners develop these skills and abilities during the learning of

Chemistry; Chemistry practical becomes helpful in improving performance in Chemistry. The findings of this study are attributed to the fact that In Science Process Skills Teaching Approach, there was learner involvement which facilitated personal growth and skills development and this resulted from the fact that learners were given an opportunity to learn the content in the school curriculum through science process skills teaching approach, which enhanced development of a variety of skills such as questioning, predicting, observing, manipulating, inferring and critical thinking. SPSTA helped to improve the quality of Chemistry practicals and good quality Chemistry practicals help in developing students' understanding of scientific process skills and concepts (Dillon, 2008) this led to better performance in Chemistry practical by the experimental group. SPTA made the nature of Chemistry practicals to be supportive to learning and the learning experiences played an important role in improving students' achievement in Chemistry practical, a view held by The House of Commons Science Technology Committee (UK, 2002). The role of the teacher was to design situations so that pupils were caused to employ research procedures to recognize problems, to ask questions, to apply investigational procedures and to provide consistent descriptions, predictions and explanations which are compatible with shared experience of the physical world which led to high performance in Chemistry practical. Science process skills exercises typically serve as the primary source of science skills development (Wilke& Straits, 2005). SPSTA improves students' performance for example in solving problems, reflecting on their work, drawing conclusions and generating prediction, qualities necessary for a high achieving student. If secondary schools in Kenya implement SPSTA in Chemistry teaching, the students' achievement at KCSE in Chemistry Practical examination is likely to improve significantly. Secondary school teachers of Chemistry are therefore encouraged to use SPSTA in their teaching.

4. Achievement of Girls and Boys Exposed to SPSTA in Chemistry Practical

Chemistry practical is a crucial part of Chemistry learning in secondary school. This is because it consists of 40% of the overall grade of the student at KCSE, hence there is need to design a teaching strategy which can boost the self-confidence in the ability to perform Chemistry practical in the learners. KCSE results indicate that the boys score higher grades in Chemistry than the girls. The study used SPSTA and there was need to find out whether the achievement in chemistry practical was significantly different between the boys and girls exposed to SPSTA since studies indicate that girls and boys of the same age tend to have different attitudes towards similar methods. This was achieved by analysing hypothesis which stated; HO2: there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical

HO2 was tested by analysis of the PCT post-test of experimental group 1 and experimental group 3 according to gender

Experimental group 1 and experimental group 3 were analysed and the means in CPT post-test are presented in table 9

Group	Mean	N	Std. Deviation
group1Boys	74.96	46	3.126
group1 Girls	75	46	4.101
group3 Boys	75.23	44	3.804
group3 Girls	73.68	46	4.247
Total	74.72	182	3.822

Table 9: Means and Standard Deviations of the Students' Achievement in CPT Post-Test According to Gender
Source: Field Data

From table 9, the means were different for all the groups and a one way ANOVA was carried out to determine whether the means were statistically significantly different and the results are in table 10

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	32.463	3	10.821	0.734	0.534
Within Groups	1267.593	86	14.739		
Total	1300.056	89			

Table 10: One Way ANOVA on the Post-Test Scores on CPT Accordingto Gender
Source: Field Data

From table 10, there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical at P <.05, F = (3, 89) = 0.734, P= .534>.05. Having established that the mean differences among the girls and boys reported in table 10 were not statistically significant from the ANOVA test, then the study found out that the achievement of boys and girls exposed to SPSTA in Chemistry practical is not statistically significantly different. A t-test on the CPT post-test scores for the experimental group1 and experimental group 3 boys and girls are presented in table 11

Variable	Gender	Mean	Std. dev.	t-value	df	p-value
CAT	Boys	75.10	4.535	1.059	89	.295
	Girls	74.34	4.594			

Table 11: CPT Post-test Scores for the Experimental Group1 and Experimental Group 3 Boys and Girls Boys, N= 90 Girls, N= 92
Source: field data

From table 4.32, (t= 1.059 and P= .295>.05), the mean differences between the boys and girls exposed to SPSTA were not statistically significant. This implies that the boys and girls exposed to SPSTA perform equally well in Chemistry practical. H02 : there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in chemistry practical was therefore retained since the ANOVA results (table 10) and t-test (table 11) show that there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical. This implies that girls and boys exposed to SPSTA will perform equally well in Chemistry practical.

5. Discussion of Results on Achievement of Girls and Boys Exposed to SPSTA in Chemistry Practical

The findings of this study are in agreement with Mwangi, (2016) who studied the effect of Chemistry practicals on students' performance in chemistry in public secondary schools in Kenya and reported that there is no significant difference in post-test performance in Chemistry by gender using practical Chemistry for experimental group. These findings are in support of the study by Oluwatosin and Ogbebu, (2017) on the effect of gender on senior secondary chemistry students' achievement in Stoichiometry using hands on activities and reported that both male and female students should be involved in hands on activities to enhance their achievement in stoichiometry since there was no significant difference in the mean achievement scores between male and female students taught stoichiometry using hands on activities. A study on the effects of cooperative class experiment teaching method on secondary school students' Chemistry achievement in Kenya reported that there was no significant difference between the boys and girls exposed to the cooperative class experiment method and that boys and girls exposed to cooperative class experiment perform equally well (Wachanga, 2004).

Ssempala, (2008) studied gender differences in performance of Chemistry practical skills among senior six students in Kampala District and his results show that there is no statistically significant differences between girls and boys in their ability to manipulate the apparatus/ equipment, take observation, report/ record results correctly and compute interpret/ analyze results during the Chemistry practical; that both female and male students perceived interpreting/ analyzing results the most difficult skill to perform, whereas manipulation of apparatus/ equipment was perceived to be the easy skill to perform during chemistry practical by both gender; however girls had a poor self-confidence in their ability to perform Chemistry practical as the boys performed slightly better than girls in recording/ reporting results correctly and computing / interpreting/ analyzing results contribute a higher percentage in the assessment of chemistry practical by the Uganda National Examinations Board examiners (UNEB) and the study attributed this to the better performance of boys than girls in UNEB Chemistry practical examinations. Busolo, (2010) study on gender differences in students' achievement in Chemistry in secondary schools in Kenya reported that boys had a stronger affinity and interest towards Chemistry than the girls and recommended that strategies to develop interest in Chemistry for girls should be developed. A study on the factors contributing to gender disparity in science academic performance in Kenya Certificate of Secondary Education in Kenya recommended that there was need to adopt teaching strategies that stimulate girls' interests in science to alleviate the gender gap (Mackatian, 2018). SPSTA on the other hand was able to stimulate the girls' interests in Chemistry and develop the girls' self confidence in their ability to perform Chemistry practical that is why there was no statistically significant difference in the achievement of boys and girls exposed to SPSTA in Chemistry practical. If teachers of Chemistry adopt SPSTA in their teaching, the achievement of students in Chemistry practical will improve and the gender gap in the achievement in Chemistry practical will be alleviated.

6. Conclusions

Based on the findings of the study, the following conclusions were made:

- Science Process Skills Teaching Approach positively influences secondary school students' achievement in Chemistry Practical more than Regular Teaching methods
- Both boys and girls will improve their achievement in Chemistry Practical when they are taught using Science Process Skills Teaching Approach

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Appendix

Chemistry Practical Test

School……Gender……

Time: 1hr 30 Min

Instructions

1. Write the name of your school and your gender in the spaces provided.
2. Answer ALL the questions in this paper in the spaces provided.
3. You are NOT allowed to start working with the apparatus for the first 10 minutes of the 1½ hour allowed for this paper. This time is to enable you read the question paper and Make sure you have all the chemicals and apparatus that you may need.

Question One.

You are provided with two solids W and T. You are required to carry out the test below andwrite your observations and inferences in the spaces provided.

Experiment Observation Inference/deduction

I Describe the appearance of solid W and T (2 marks)

Solid W

Solid T

II Place a spatula of solid W in a test tube. Add about 6cm^3 of distilled water and shake well.

Test the solution W with red and blue litmus paper

Observation	Inference
(1 mark)	(1 mark)

III Repeat the same procedure II above with solid T

Observation	Inference
(1 mark)	(1 mark)

IV Place a spatula end full of solid W in a dry test tube. Heat the solid over a Bunsen burner gently and then strongly. Test for any gases evolved with: A glowing wooden splint, moist red and blue litmus paper and Calcium hydroxide

Observation	Inference
(1 mark)	(1 mark)

V Repeat the procedure in IV above with solid T

Observation	Inference
(1 mark)	(1 mark)

Question Two

You are provided with two solutions, lead nitrate and magnesium sulphate. Put 10cm^3 of lead nitrate in a beaker. To the same beaker, add excess magnesium sulphate solution. Mix the solution using a glass rod. Let the solid settle, pour off the liquid, wash the solid with distilled water. Filter and dry the solid between filter papers

Answer the following questions

I which ions are present in the reactant? (2mks)

II What observations are made when lead (ii) nitrate and magnesium sulphate solutions are mixed (1mk)

III Name the salt you have prepared in this experiment (1mk)

IV Write a balanced equation for the reaction (1mk)