3.5 CHEMISTRY (233)

Chemistry is tested in three papers, paper 1 (233/1), paper 2 (233/2) and paper 3 (233/3). Paper 1 and paper 2 are theory papers while paper 3 is a practical. Paper 1 (233/1) tests Forms 1, 2, 3 and 4 content whereby each question carries a maximum of 3 marks while paper 2 tests content from specific topics from forms 1, 2, 3, and 4. A question in paper 2 can carry up to a minimum of 10 and a maximum of 14 marks. Paper 3 tests both quantitative and qualitative practical skills attained by the candidates from forms 1, 2, 3 and 4.

This report is based on the analysis of performance of candidates who sat the year 2019 KCSE Chemistry.

3.5.1 CANDIDATES GENERAL PERFORMANCE

The following table shows the performance of Chemistry in the last five years.

Table 12: Candidates Performance in Chemistry for the last five years: 2015, 2016, 2017, 2018 and 2019

Year	Paper	Candidature	Maximum Score	Mean Score	Standard Deviation
2015	1		80	26.83	15.78
	2		80	22.07	13.45
	3		40	20.37	7.15
	Overall	**515,888**	**200**	**68.71**	**33.29**
2016	1		80	19.15	14.85
	2		80	14.66	12.85
	3		40	13.63	6.31
	Overall	**566,836**	**200**	**47.42**	**34.01**
2017	1		80	17.03	14.67
	2		80	17.97	14.32
	3		40	14.1	6.11
	Overall	**606,515**	**200**	**48.09**	**32.87**
2018	1		80	19.36	14.57
	2		80	16.96	14.17
	3		40	14.44	6.45
	Overall	**656,163**	**200**	**53.76**	**33.45**
2019	1		80	20.00	14.98
	2		80	18.00	13.07
	3		40	13.00	6.70
	Overall	**691,802**	**200**	**52.17**	**32.71**

From the table, it is observable that:

(i) Candidature for chemistry increased from **656,163** in 2018 to **691,802** in 2019 an increment of about 5.4 %. Candidature has been improving over the years.

(ii) Performance in paper 1 improved slightly with 0.64 units from a mean of 19.36 to a mean of 20.00. The increment was equivalent to 3.31 %;

(iii) Performance in paper 2 improved minimally with 1.04 units from a mean of 16.96 in 2018 to 18.00 in 2019. This was an increase of 6.1%;

(iv) Performance in paper 3 declined from a mean of 14.44 to 13.00 an equivalence decrease of 9.97%.

(v) The standard deviation in the theory papers remained near the ideal indicating that the test items were able to discriminate between low and high achievers. The near ideal SDs shows that the papers were balanced in terms of difficulty versus easiness. However, the standard deviation of the practical paper was 6.70 which is small compared to the ideal standard deviation.

(vi) The overall performance of Chemistry declined from a mean of 53.76 (26.88%) in 2018 to 52.17 (26.09%) in 2019 a decrease of 1.59 points equivalent to 2.96%. Teachers are advised to teach the syllabus but not the text books in order to cover the entire content. A variety of text books authorized by the curriculum body should be used for instruction but not one recommended text book.

(i) ANALYSIS OF QUESTIONS PERFORMED POORLY

Questions which were performed poorly are analysed and briefly discussed below. The discussion is based on comments from the chief examiners reports and analysis of the candidates' responses from the sampled answer scripts.

3.5.2 Chemistry Paper 1 (233/1)

The questions which were reported to have been poorly performed are briefly discussed below in view of pointing out the candidates' weaknesses and the proposed suggestions on the measures to be put in place in order to improve performance in future.

Question 7

A solution contains 40.3 g of substance XOH per litre. 25.0 cm^3 of this solution required 30.0 cm^3 of 0.3 M sulphuric(VI) acid for complete neutralisation.

(a) Calculate the number of moles of XOH that reacted. ($1^1/_2$ marks)

(b) Determine the relative atomic mass of **X**. ($1^1/_2$ marks)
(O = 16.0 ; H =1.0)

Requirements

Candidates were required to calculate the moles of XOH that reacted and to determine the relative atomic mass of X.

Weaknesses

Many candidates had challenges in getting the mole ratio hence unable to use the moles of sulphuric (VI) acid to obtain the concentration of XOH.

Expected Response

(a) $H_2SO_4(g) + 2XOH(aq) \rightarrow X_2SO_4(aq) + 2H_2O(l)$

1 : 2

Moles of $H_2SO_4 = \frac{30 \times 0.3}{1000} = 0.009$ moles

Moles of XOH = 2 x 0.009

= 0.018 moles

(b) Molarity of XOH $= \frac{0.018 \times 1000}{25}$

= 0.72M

$R.F.M = \frac{g/l}{molaity} = \frac{40.3}{0.72} = 55.972$

$RFM = \frac{g/l}{molaity} = \frac{40.3}{0.72} = 55.972$

= 56

$x + 16 + 1 = 56$

$x = 56 - 17$

$x = 39$

Advice to teachers

Teachers should put emphasis on calculations involving molar solutions and present the learners with opportunities for more practice on questions on the mole and related questions.

Question 19

Given that the $E^{\ominus}$ of Cu(s) /Cu^{2+}(aq) is + 0.34 V and that of Zn (s)/Zn^{2+}(aq) is - 0.76 V, draw a labelled diagram of zinc and copper electrochemical cell. (3 marks)

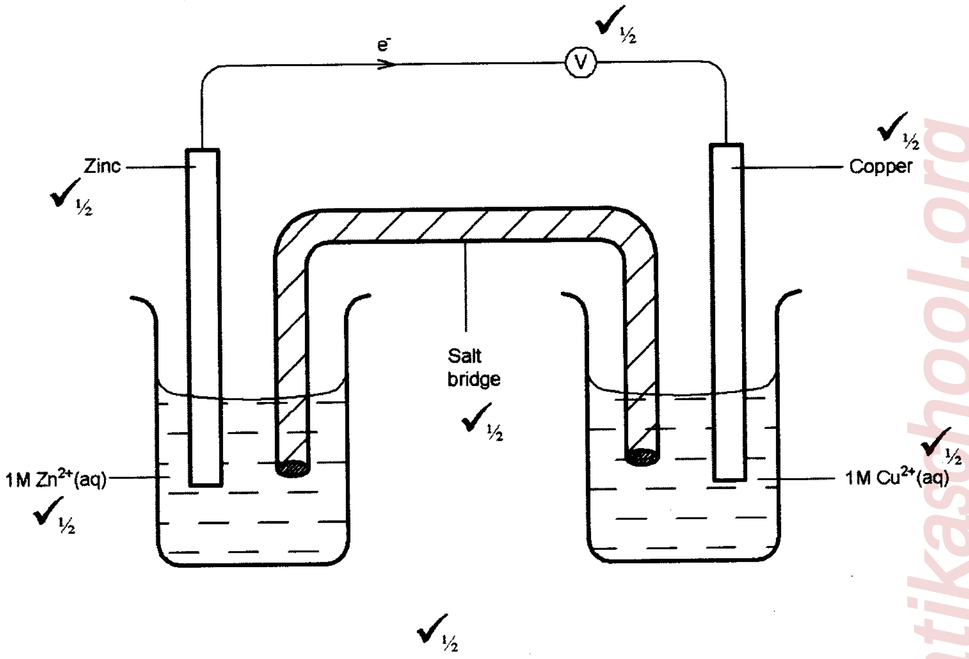
Requirements

In this question, candidates were required to draw and label an electrochemical cell made of zinc and copper half-cells.

Weaknesses

Majority of the candidates could not draw the cell correctly and used a battery instead of a voltmeter.

Expected Response



Advice to teachers

Teachers should apply practical approach when handling the topic Electrochemistry so that the learners can be able to see the electrochemical cells practically and to be able to see how the cells are made.

Question 28

Draw in the space provided a labelled diagram of the set-up of the apparatus that can be used to electrolyse molten lead(II) bromide. (3 marks)

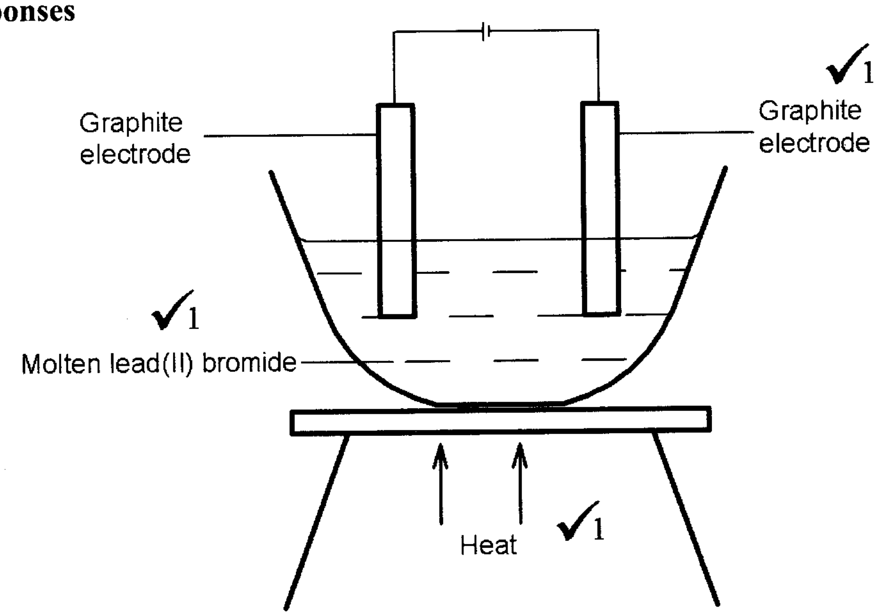
Requirements

This questions required candidates to draw the set-up of the apparatus used to electrolyse molten lead(II) bromide.

Weaknesses

Most of the candidates failed to indicate heat in the set up. Others could not identify the type of electrodes suitable for the electrolysis.

Expected Responses



Advice to teachers

Teachers should apply practical approach when teaching electrolysis so that learners are able to interact with and see the actual set up of the apparatus.

3.5.3 Chemistry paper 2 (233/2)

Question 5

(a) What is meant by molar heat of neutralisation? (1 mark)

(b) In an experiment to determine the molar heat of neutralisation, 50 cm^3 of 1M hydrochloric acid was neutralised by adding 10 cm^3 portions of dilute sodium hydroxide. During the experiment, the data in **Table 1** was obtained.

Table 1

Volume of Sodium hydroxide (cm^3)	0	10	20	30	40	50	60
Temperature of mixture (°C)	25.0	27.0	29.0	31.0	31.0	30.0	29.0

(i) Write the equation for the reaction in this experiment. (1 mark)

(ii) On the grid provided, plot a graph of temperature (Y-axis) against volume of sodium hydroxide (x-axis) added. (3 marks)

(iii) Determine from the graph the:

I. volume of sodium hydroxide which completely neutralises 50.0 cm^3 of 1.0M hydrochloric acid. (1 mark)

II. change in temperature, ΔT, when complete neutralisation occurred. (1 mark)

(iv) Calculate:

I. the heat change, ΔH when complete neutralisation occurred.
(Specific heat capacity = 4.2 $Jg^{-1} K^{-1}$, density of solution 1.0 gcm^{-3}) (2 marks)
II. molar heat of neutralisation of hydrochloric acid with sodium hydroxide. (1 mark)

(v) How would the value of molar heat differ if 50.0 cm^3 of 1.0M ethanoic acid was used instead of 1.0M hydrochloric acid? Give a reason. (2 marks)

Requirements

The question required candidates to apply knowledge on enthalpy changes to draw a graph of the reaction and deduce some data from the graph.

Weaknesses

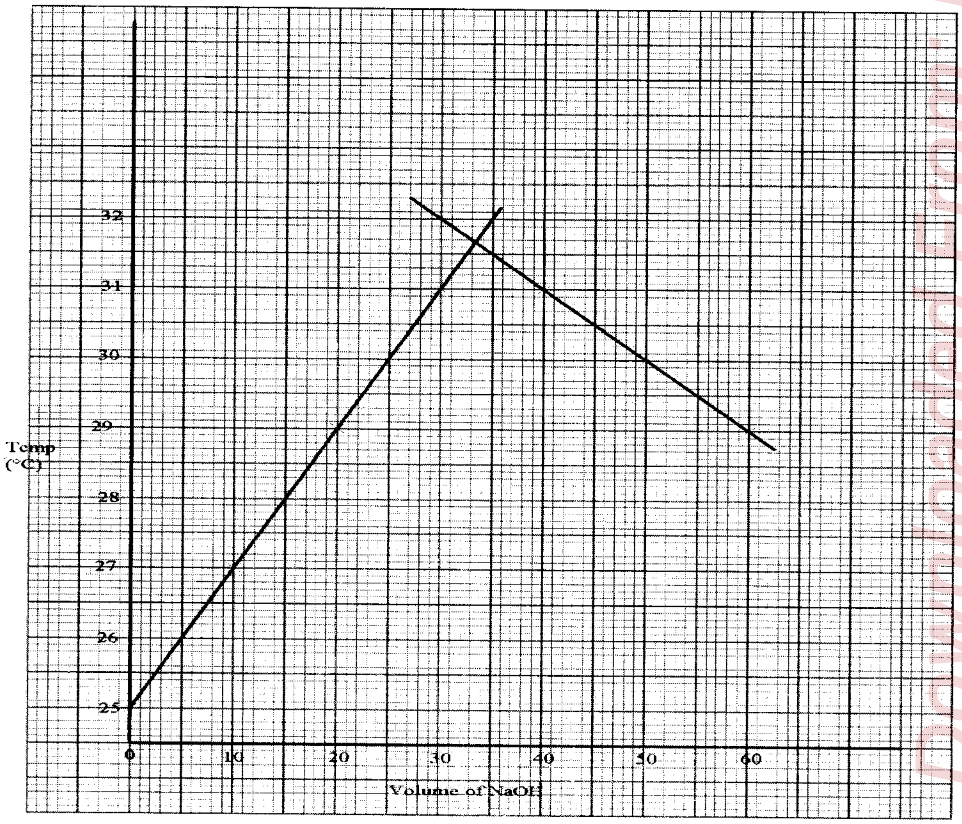
Majority of the candidates were not able to apply the knowledge of extrapolation to determine the highest temperature change but just used the highest and lowest temperatures from the table to determine ΔT.

Expected Responses

(a) Heat change that occurs when one mole of OH^- ions reacts with one mole of H^+ ions to form 1 mole of water.

(b) **(i)** $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

(ii)



(iii) I. Volume of sodium hydroxide (correct value read from the graph)

From graph $33.5cm^3$

II. $\Delta T = 31.65 - 25.0 = 6.65°c$ / ΔT = value from the graph – 25

(iv) I. $\Delta H = 83.5 \times 4.2 \times 6.65$ / value from the graph + $50 \times 4.2 \times \Delta T$
$= 2332.155$ J

II. Moles of HCl $= \frac{50x1}{1000}$ OR $\frac{\text{Ans from (vi)I.}}{0.05}$

$= 0.05$

0.05 moles $= 2332.2$

1 mole $= \frac{2332.2}{0.05}$
$= -46.64kJmol^{-1}$

(v) The molar heat of ethanoic acid would be lower. Ethanoic acid is a weak acid and thus not some of the heat energy is utilized in ionizing the acid.

Advice to teachers

Teachers should guide learners on skills for drawing graphs and apply practical approach in the teaching of this topic.

Question 7

(a) What is meant by rate of reaction. (1 mark)

(b) In the space provided, sketch the diagram of a set-up that can be used to determine the rate of reaction between manganese(IV) oxide and hydrogen peroxide. (3 marks)

(c) A student placed a small amount of liquid bromine at the bottom of a sealed gas jar of air as shown in **Figure 4**.

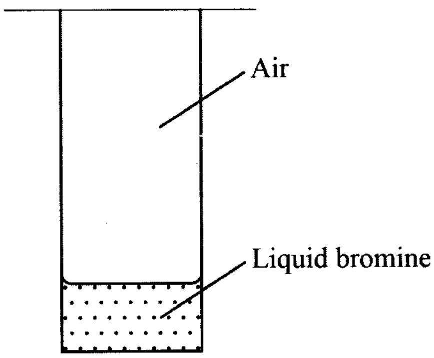


Figure 4

(i) Describe what will be observed: (1 mark)
I. after two minutes
II. after 30 minutes

(ii) Use the Kinetic theory to explain the observations: (2 marks)
I. after 2 minutes
II. after 30 minutes

(d) Some plants have seeds that contain vegetable oil.

(i) Describe how the oil can be obtained from the seeds. (3 marks)
(ii) Explain how it could be confirmed that the liquid obtained from the seeds is oil. (1 mark)

Requirements

Candidates were required to define rate of a reaction, draw a set- up that can be used to investigate rate of decomposition of hydrogen peroxide using manganese(IV) oxide as a catalyst and to describe the observations made when bromine liquid diffuses.

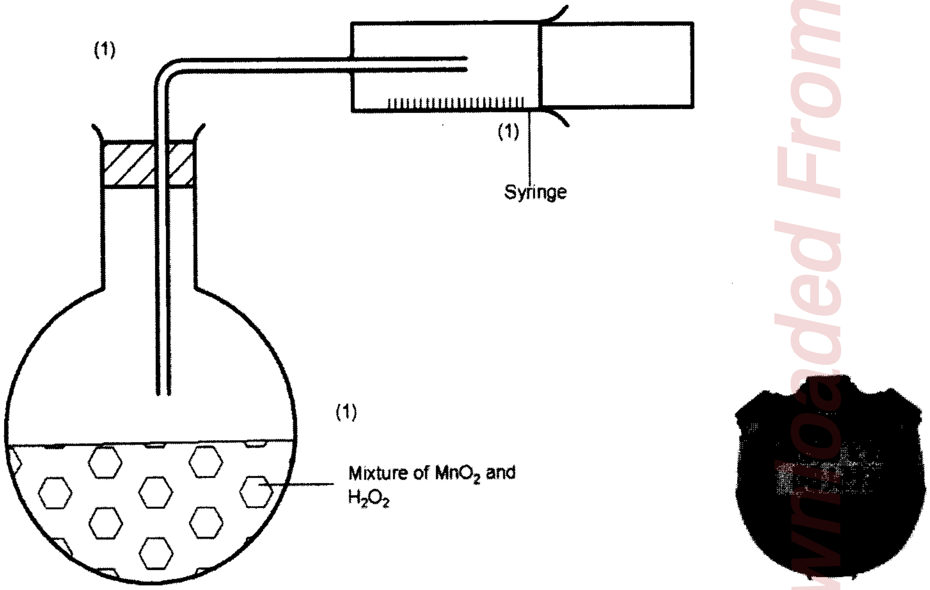
Expected Responses

(a) Rate = $\frac{\text{change in concentration of reagents/products}}{\text{time}}$

or

Reaction rate is a measure of how much of reactants are consumed or how much products are formed per unit time.

(b)



- Workability - 1 mark
- Means of measuring the gas - 1 mark
- Means of timing (stop watch)

(c) (i) I. After two minutes, red/brown colour fumes of bromine are observed on the surface of the bromine liquid.

II. After 30 minutes, the gas jar is filled with yellow fumes.

(ii) I. Bromine liquid is volatile, the molecules escape from the liquid but the vapour being denser than air will occupy the space on the surface of the liquid.

II. Since molecules in the vapour phase move randomly, with time, bromine molecules will undergo collisions with air molecules and mix thus filling the gas jar.

(d) (i)

- The seeds are crushed in a mortar with a pestle to increase surface area for oil extraction.
- Then a solvent (ethanol/acetone) is added with continued crushing. The liquid is then decanted into an evaporating dish.
- The evaporating dish is placed out into the sun to allow solvent to evaporate because of its low RMM, leaving behind the oil.

(ii) The liquid left after evaporation is placed on a piece of paper. If it leaves a translucent mark, then it is oil.

Advice to teachers

Teachers should apply practical approach when teaching rates of reactions and diffusion in air, liquid and solids.

3.5.5 Chemistry paper 3 (233/3)

The practical paper was tested using three questions. Question 1 tested skills and competencies on rate of a reaction. **Question 1** tested Knowledge, skills and competencies on:

- Manipulation of apparatus;
- Measuring volumes of solutions;
- Making observations;
- Measuring temperature;
- Measuring, reading and recording time using clocks /stop watches;
- Data manipulation;
- Calculations;
- Drawing a graph rate of the reaction;
- Data interpretation.

Question 2 involved qualitative analysis of an inorganic compound while **question 3** involved qualitative analysis of an organic liquid. The two questions demanded the candidates to perform experiments using appropriate apparatus, make accurate observations, record the observations made and infer correctly. Majority of the candidates were able to make correct observations with quite a number of them not able to distinguish between a white precipitate from a white sublimate. However, the candidates experienced challenges in making inferences where they had difficulties in giving the correct inferences.

Question 1 was identified to have challenged most of the candidates

Question 1

You are provided with:
- **Solution A** : aqueous Iron(III) sulphate.
- **Solution B** : aqueous potassium iodide.
- **Solution C** : mixture of aqueous starch and sodium thiosulphate solution.

You are required to determine the rate of reaction between aqueous Iron(III) sulphate (**solution A**) and aqueous potassium iodide (**solution B**).

Procedure:

(i) Place 5 test tubes on a test tube rack and label them **1, 2, 3, 4** and **5**. Fill a burette with **solution A**. To each test tube place 3 cm^3 of solution A from the burette.

(ii) Clean the burette and fill it with **solution B**. Place 8 cm^3 of solution B into a 100 ml beaker from the burette.

(iii) Using a 10 ml measuring cylinder, add 2 cm^3 of **solution C** to the beaker containing **solution B** followed by 7 cm^3 of distilled water measured using the same 10 ml measuring cylinder.

(iv) Pour the contents of test tube 1 to the mixture in the beaker and immediately start the stop watch. Swirl the contents of the beaker. Record in **table 1** the time taken for a blue colour to just appear. Measure the temperature of the final mixture and record in the space provided. Wash the beaker and proceed to step (v).

(v) Place 6 cm3 of **solution B** into 100 ml beaker from the burette. Add 2 cm^3 of solution C followed by 9 cm^3 of distilled water. Add solution A in test tube 2 to the mixture in the beaker and immediately start the stop watch. Swirl the contents of the beaker. Record in **table 1** the time taken for a blue colour to just appear. This is experiment 2.

(vi) Wash the beaker. Repeat step (v) with solution A in test tubes 3, 4 and 5 with corresponding volumes of solution B, solution C and distilled water as indicated in **table 1** for experiments **3**, **4** and **5**.

(a) Temperature of final mixture _______________ °C (1 mark)

Table 1

Experiment	**Volume (cm^3) of**				**Time (seconds)**
	Solution A	**Solution B**	**Solution C**	**Distilled Water**	
1	**3**	8	2	7	
2	3	6	2	9	
3	3	5	2	10	
4	3	4	2	11	
5	3	3	2	12	

(3 marks)

(c) Complete **table 2** for each experiment by:

(i) calculating the square of **volume of solution B, B2** and filling in the table.

(ii) calculating the rate of reaction which is given by the expression **Rate** = s^{-1} and filling in the table.

Table 2

Experiment	**B²**	**Rate** = s^{-1}
1		
2		
3		
4		
5		

(5 marks)

(d) Plot a graph of rate (y-axis) against B^2.

(e) Using the graph, determine the time that it will take for the blue colour to appear if the experiment is repeated using the following mixture:

Volume (cm^3) of			
Solution A	**Solution B**	**Solution C**	**Distilled water**
3	7	2	8

(2 marks)

(f) In this experiment the rate of reaction was determined with respect to potassium iodide. Describe how the rate of the reaction can be determined with respect to Iron(III) sulphate. (2 marks)

Requirements

Candidates were required to manipulate apparatus to measure volumes of solutions, make the observations on colour change, measure and record temperature, measure and record time using clocks /stop watches, manipulate data, perform some calculations, draw a graph of rate against $\mathbf{B}^2$ and interpret the graph.

Weaknesses

Majority of the candidates were unable to read and record time accurately, choose a suitable scale for the graph, interpret the graph, convert time to rate correctly, perform mathematical manipulations and describe experimental procedure correctly.

Expected Responses

(a) 22.5 ^{0}C

(b) **Table 1**

Experiment	Time (seconds)
1	14.1
2	22.0
3	32.0
4	49.0
5	78.2

Complete table.. $1\frac{1}{2}$ marks

Decimal.. $\frac{1}{2}$ mark

Accuracy.. $\frac{1}{2}$ mark

Trend.. $\frac{1}{2}$ mark

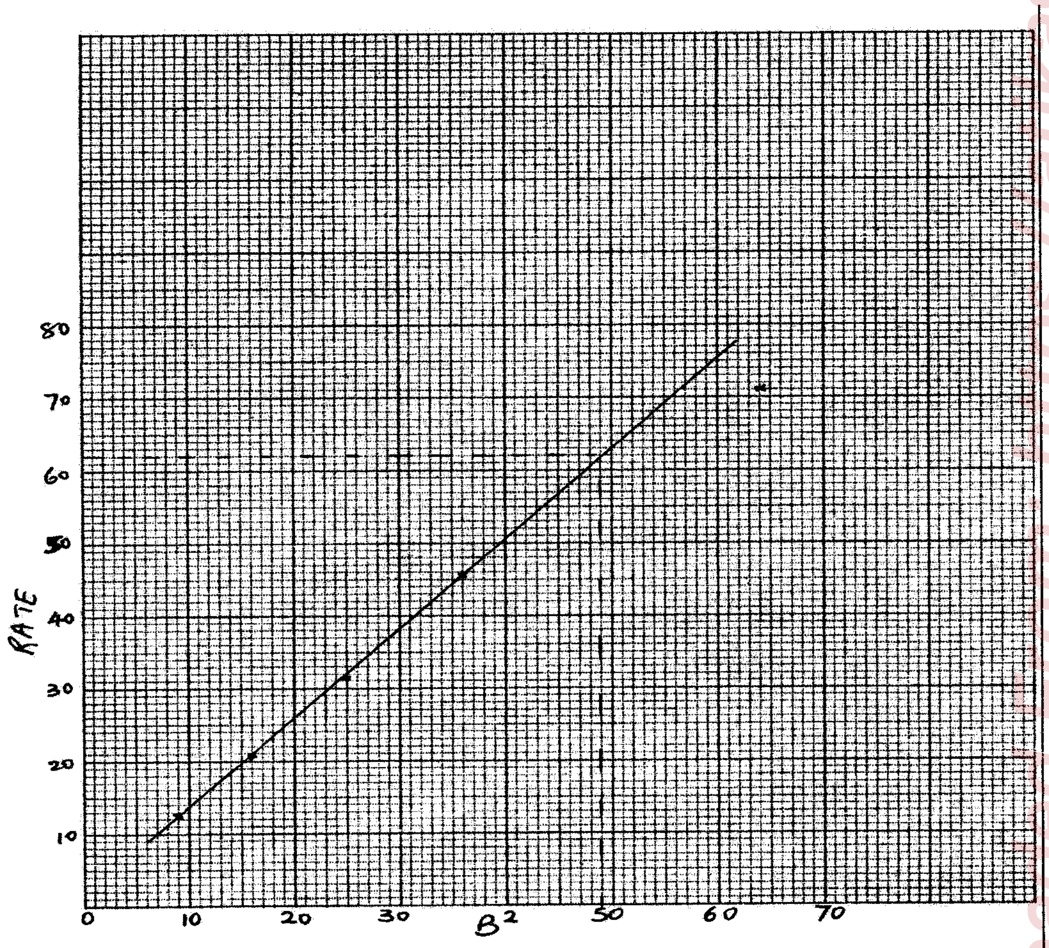
(c) **Table 2**

Experiment	B^2	Rate = s^{-1}
1	64	70.9
2	36	45.5
3	25	31.3
4	16	20.4
5	9	12.8

Note: All points lie on a straight line except for B = 8, B^2 = 64, rate = 70.9 s^{-1}

- Correctly worked B^2.....................................$^1/_2$ for each value to a maximum of $2^1/_2$ marks
- Correctly worked rate..................................$^1/_2$ for each value to a maximum of $2^1/_2$ marks

(d)



(e) B = 7, B^2 = 49
From the graph, Rate = = 62
Time = = 16.1 seconds

(f) Keep volume of solution **B** and solution **C** constant. Use different volumes of solution **A**. Calculate appropriate volume of distilled water to use to make total volume constant.

Advice to teachers

Teachers should make use of practical approach to the teaching and learning of Chemistry. Emphasis should be on calculations, manipulation of data, graph interpretation and the use of correct scientific terms in reporting observations and inferences. Teachers are advised to expose learners to as many practicals as possible in order to give them an opportunity to interact with apparatus and chemicals.

CONCLUSION

There was a decline in performance of Chemistry in all the three papers. It is worth noting that part of the practical examination involves the ability of the learners to follow instructions in carrying out the tests. Teachers should therefore train their learners to perform experiments with strict adherence to the instructions. This will enable them attain the expected results without challenges.