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 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 2018 KCSE Chemistry examination.

3.5.1 CANDIDATES GENERAL PERFORMANCE

The following Table shows candidates performance in Chemistry in the last five years.

Table 14: Candidates Performance in Chemistry in the last five years: 2014, 2015, 2016, 2017 and 2018

Year	Paper	Candidature	Maximum Score	Mean Score	Standard Deviation
2014	1		80	25.44	15.79
	2		80	21.33	13.46
	3		40	17.57	6.19
	Overall	**476,582**	**200**	**64.31**	**35.63**
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**

From the Table, it can be observed that:

(i) Candidature for Chemistry increased from **606,515** in 2017 to **656,163** in 2018 an increment of about 8.2%. Candidature has been improving over the years.

(ii) Performance in Paper 1 improved from a mean of 17.03 to 19.36. This was an improvement of 13.68%;

(iii) Performance in Paper 2 declined from a mean of 17.97 to 16.96. This was a decrease of 5.6%;

(iv) Performance in Paper 3 improved slightly from a mean of 14.1 to 14.44 an equivalence of 2.4%.

(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 easy test items.

(v) The overall performance in Chemistry improved from a mean of 48.09 (24.05%) in 2017 to 53.76 (26.88%) in 2018 an increment of 5.67 points equivalent to 11.8%. This significant improvement could be a pointer to students taking charge of their learning and the teachers offering them opportunities to demonstrate what they have learned through revision.

3.5.2 ANALYSIS OF QUESTIONS PERFORMED POORLY

Questions which were performed poorly are analyzed 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.

3.5.3 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 3
The following are formulae of organic compounds. Use the formulae to answer the questions that follow:

$CH_3CH_2CH_2OH$;

CH_3COOH ;

$CH_3CH_2CH_2CH_3$;

CH_3CCCH_3 .

(a) Select:
(i) **two** compounds which when reacted together produce a sweet smelling compound. (1 mark)
(ii) an unsaturated hydrocarbon. (1 mark)
(b) Name the compound selected in (a) (ii). (1 mark)

Requirements
The question required candidates to select a pair of compounds which could form an ester and name an organic compound.

Weaknesses
Many candidates could not select reagents that could form an ester. They were also unable to identify and name an alkyne.

a) (i) $CH_3CH_2CH_2OH$ and CH_3COOH

(ii) CH_3CCCH_3

b) But-2-yne

Advice to teachers
Teachers should put emphasis on nomenclature of organic compounds in the different homologous series. Students should be provided with opportunities to do more practice on naming and drawing structures of organic compounds.

Question 14
Figure 3 shows a set-up used by a student to prepare dry chlorine gas in the laboratory.

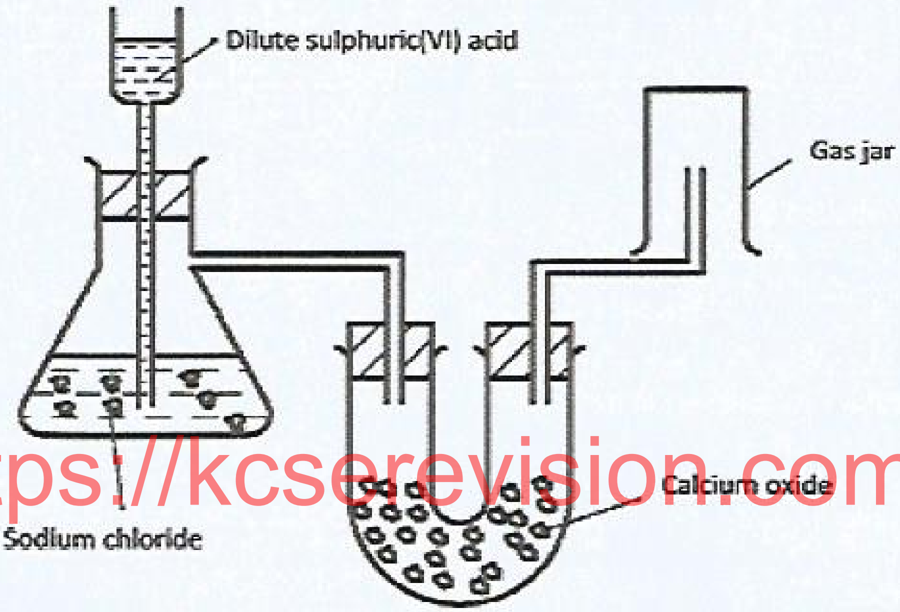


Figure 3

Identify **three** mistakes in the set-up, and give a reason for each. (3 marks)

Requirements
In this question, candidates were required to identify with reasons the mistakes in the set up.

Weaknesses
Most of the candidates focused on the assembling of the apparatus than the reagents

Expected Response
- One reagent is missing, hence reagents provided cannot produce chlorine;
- Wrong drying agent
- Calcium oxide will react with the chlorine gas;
- Incorrect method of gas collection
- No gas will be collected / chlorine is denser than air.

Advice to teachers
Teachers should use practical approach when teaching preparation of gases. Students should be allowed to participate in assembling the apparatus.

Question 16

Metal **X** and **Y** have standard electrode potentials of +0.13 V and -0.76 V respectively. The metals were connected to form a cell as shown in **Figure 4.**

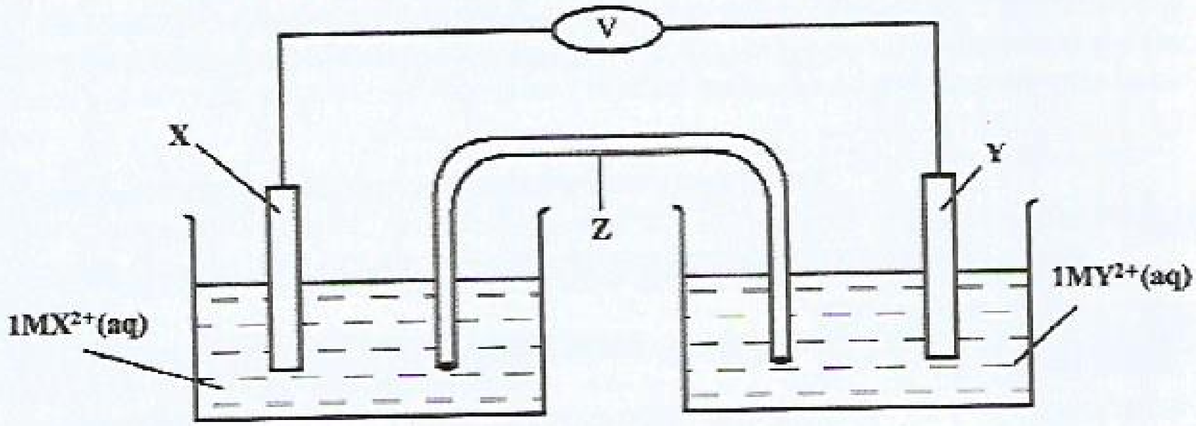


Figure 4

(a) Name the part labelled **Z**. (1 mark)

(b) State **one** function of the part labelled **Z**. (1 mark)

(c) Calculate the e.m.f. of the cell. (1 mark)

In this question, candidates were required to name a part of an electrochemical cell and to state one of its uses hence calculate the e.m.f of the cell

Weaknesses

Most of the candidates were unable to identify the reduced and oxidised half cells.

Expected Responses

(a) Salt bridge

(b) - Provides electrical contact between the electrodes//completes the circuit;

- Provides cations and anions to replace those used up.

(c) e.m.f of cell = E^{θ} reduced - E^{θ} oxidized

$= -0.13 - -0.76$

$= +0.63V$

Advice to teachers

Teachers should guide students on how to identify the oxidized and the reduced half cells in an electrochemical cell based on the signs on the E^{θ} values. Learners should be exposed to all experiments and projects a given in the syllabus in order to acquire skills necessary to handle practical-based test items.

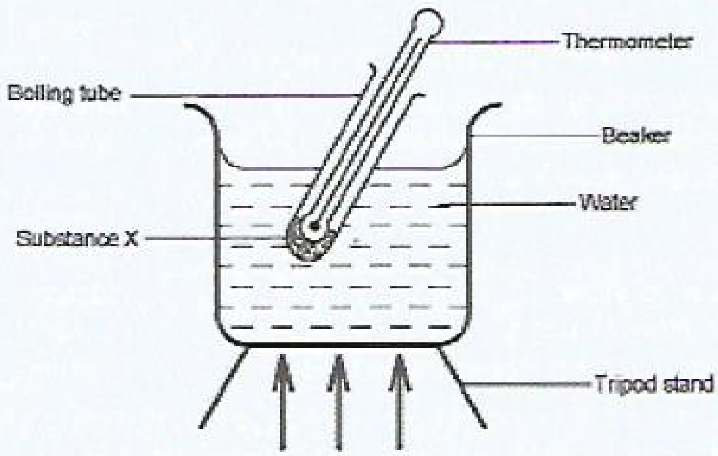
Question 22

You are provided with the following: thermometer, boiling tube, beaker, Bunsen burner, pure substance **X** whose boiling point is about 80°C, water and any other apparatus that may be required. Draw a labelled diagram of the set-up that can be used to determine the melting point of **X**. (3 marks)

Requirements
The question tested candidates' ability to draw and label the set-up of apparatus used to determine the melting point of a solid.

Weaknesses
Majority of the candidates were unable to draw labelled workable diagram.

Expected response



½ mark each to a maximum of 3

Advice to teachers
Teachers should guide students on assembling apparatus for different experiments and drawing of diagrams for the set-ups. Experiments should involve assembling of the apparatus by the students and accompanied by a drawing illustrating the same.

3.5.4 Chemistry Paper 2 (233/2)

Question 1
The diagram in **Figure 1** shows some natural and industrial processes. Study it and answer the questions that follow.

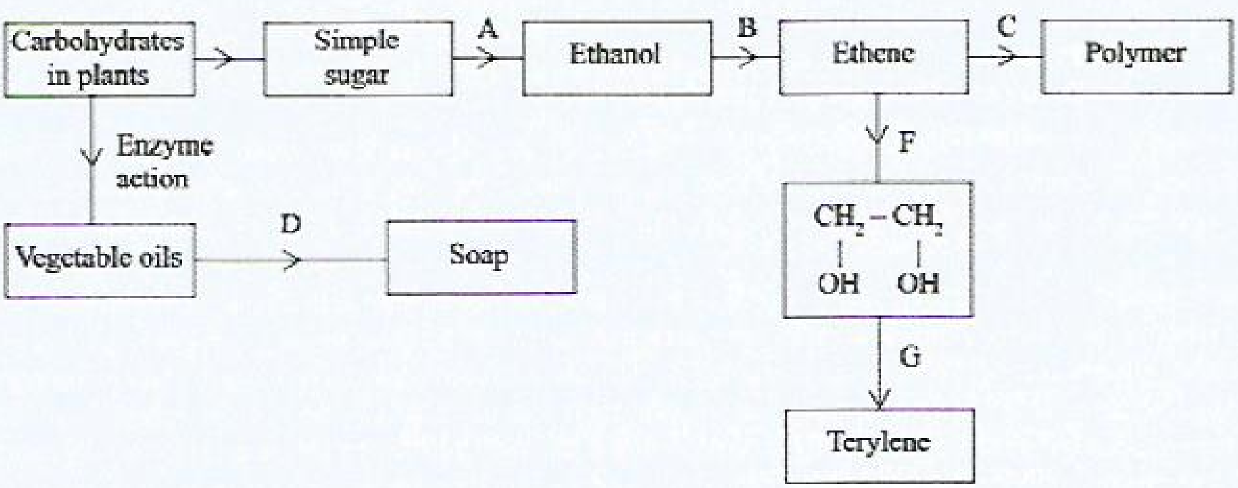


Figure 1

(a) Identify the processes labelled: (2 marks)

A
B
C
D

(b) State the reagents and conditions required for processes **B** and **D**.

(i) Process **B**:
Reagent (1 mark)
Conditions (1 mark)

(ii) Process **D**:
Reagent (1 mark)
Conditions

(iii) Describe how process **D** is carried out. (2 marks)

(iv) State **two** additives used to improve the quality of soap. (1 mark)

(c) State the reagents required in steps F and **G**.

(i) **F** (1 mark)

(ii) **G** (1 mark)

(iii) Draw the structure of terylene. (1 mark)

(d) (i) Name the polymer formed in step C. (1 mark)

(ii) State **one** disadvantage of the polymer formed in (d) (i). (1 mark)

Requirements

The question required candidates to analyse a flow chart in order to identify the reagents, conditions, processes involved at the various stages, name and draw structures of compounds formed and to state disadvantages of artificial polymers.

Weaknesses

Many candidates were not able to identify reagents and conditions correctly, draw the structure if terylene and describe the steps involved in preparation of soap.

Expected Responses

a) **A** – Fermentation
B – Dehydration
C – Addition polymerization / polymerization
D – Saponification

b) (i) Process **B**
Reagent – Concentrated sulphuric(VI) acid
Conditions – Temperature of 160°C - 180°C.

OR

-Al_2O_3
-Temperature 300 °C

OR

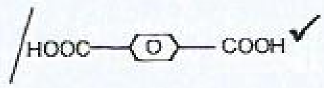
- H_3PO_4
- warm

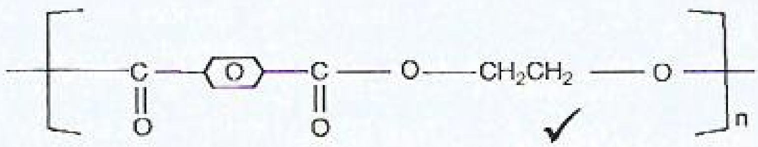
(ii) Process **D**
Reagent – Potassium hydroxide / Sodium hydroxide
Condition -Boil / Boiling

(iii) The vegetable oil is mixed with sodium hydroxide and boiled.
Solid sodium chloride is added to the resulting mixture, to precipitate out the soap from glycerol.

(iv) Perfume and builders / tetraoxophosphates / dye.

c) (i) Step **F** – acidified potassium manganate (VII)

(ii) Monomer G – Benzene – 1, 4 - dioic acid 

(iii) 

d) (i) Polyethene / polythene

(ii)
- It is non-biodegradable hence pollutes the environment;
- Produces poisonous gases when burnt.

Advice to teachers
Teachers should help the learners to perform experiments on soap preparation. There is need to expose learners to flow charts and reaction schemes after every topic to help summarize the content. This way, they will get used to test items involving use of diagrams and flow charts.

3.5.5 Chemistry Paper 3 (233/3)

The practical paper was tested using three questions. Question 1 tested skills competencies in enthalpy change and the mole. **Question 1** tested Knowledge, skills and competencies on:

- Measuring accurately volumes of solutions;
- Recording accurately such measured volumes;
- Measuring and recording times using clocks /stop watches;
- Measuring and recording temperatures;
- Manipulation of apparatus;
- Interpreting results from a table;
- Performing titrations and recording of correct titre values;
- Analyzing and interpreting the results;
- Carry out calculations involving moles and enthalpy changes.

Majority of the candidates seemed to have acquired the aforementioned skills. However, a number of the candidates displayed inefficiencies by carrying out the experiment and recording the data in the tables and not attempting the calculations. Calculations remain a major challenge to the learners.

Question 2 involved qualitative analysis of an inorganic compound while question 3 involved qualitative analysis of an organic compound. The two questions demanded the candidates to perform experiments using appropriate apparatus, make observations, record the observations 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 solution. However, the candidates experienced challenges in making inferences where learners have difficulties in giving the correct inferences.

Question 1 was identified to have challenged most of the candidates.

Question 1

You are provided with:
- 0.30 g **solid A,** magnesium metal
- Hydrochloric acid, **solution B**
- 0.15M sodium carbonate, **solution C**
- Methyl orange indicator

You are required to determine the:
- Enthalpy change, ΔH per mole, of the reaction between magnesium metal and excess hydrocholoric acid.
- Concentration in moles per litre of hydrochloric acid, **solution B**.

PROCEDURE I

(i) Using a burette, measure 50.0 cm^3 of **solution B** and place it in a 100 ml plastic beaker.

(ii) Measure the temperature of **solution B** in the beaker after every 30 seconds and record it in **Table 1.**

(iii) At the 90th second, add **all** of the **solid A** provided into the beaker, stir with the thermometer and continue measuring and recording the temperature after every 30 seconds. Complete **Table 1. Retain the mixture in the beaker for use in procedure II.**

Table 1

Time (seconds)	0	30	60	90	120	150	180	210	240	270
Temperature (°C)				X						

(3 marks)

(a) Plot a graph of temperature (vertical axis) against time on the grid provided. (3 marks)

(b) Determine the change in temperature, ΔT, for the reaction. Show the working on the graph. ΔT = (1 mark)

(c) Calculate the heat change, in joules, for the reaction. Assume that for the solution, specific heat capacity is $4.2\,J\,g^{-1}K^{-1}$ and density is $1.0\,g\,cm^{-3}$. (2 marks)

(d) The relative atomic mass of magnesium is 24.0. Calculate the enthalpy change, ΔH, of the reaction per mole of magnesium. Indicate the sign of ΔH. (1 mark)

PROCEDURE II

(i) Fill a **clean** burette with the 0.15M sodium carbonate, **solution C.**

(ii) Place **all** of the mixture in the beaker from **procedure I** into a 250 ml volumetric flask. Add distilled water to the mark and shake thoroughly. Label the mixture as **solution D.**

(iii) Using a pipette filler, pipette 25.0 cm^3 of **solution D** into a 250 ml conical flask and add 2 drops of methyl orange indicator.

(iv) Titrate **solution D** in the conical flask with the sodium carbonate, **solution C** and record the readings in **Table 2.**

(v) Repeat steps **(iii)** and **(iv)** and complete **Table 2.**

Table 2

	I	II	III
Final burette reading			
Initial burette reading			
Volume of **solution C** used (cm^3)			

(3 marks)

(a) Determine the average volume of the 0.15M sodium carbonate, **solution C**, used.

(b) Calculate the number of moles of:

(i) sodium carbonate used. (1 mark)

(ii) hydrochloric acid in the 25.0 cm^3 of **solution D.** (1 mark)

(iii) hydrochloric acid in the 250 cm^3 of **solution D.** (1 mark)

(iv) hydrochloric acid that reacted with magnesium metal. (1 mark)

(v) total number of moles of hydrochloric acid in the 50.0 cm^3, **solution B.** (1 mark)

(c) Determine the concentration of hydrochloric acid in moles per litre, in **solution B.** (1 mark)

Weaknesses

Many of the candidates could not correctly draw the graph and carry out the calculations to the end. This points to lack of practice in graph work and calculations on the mole.

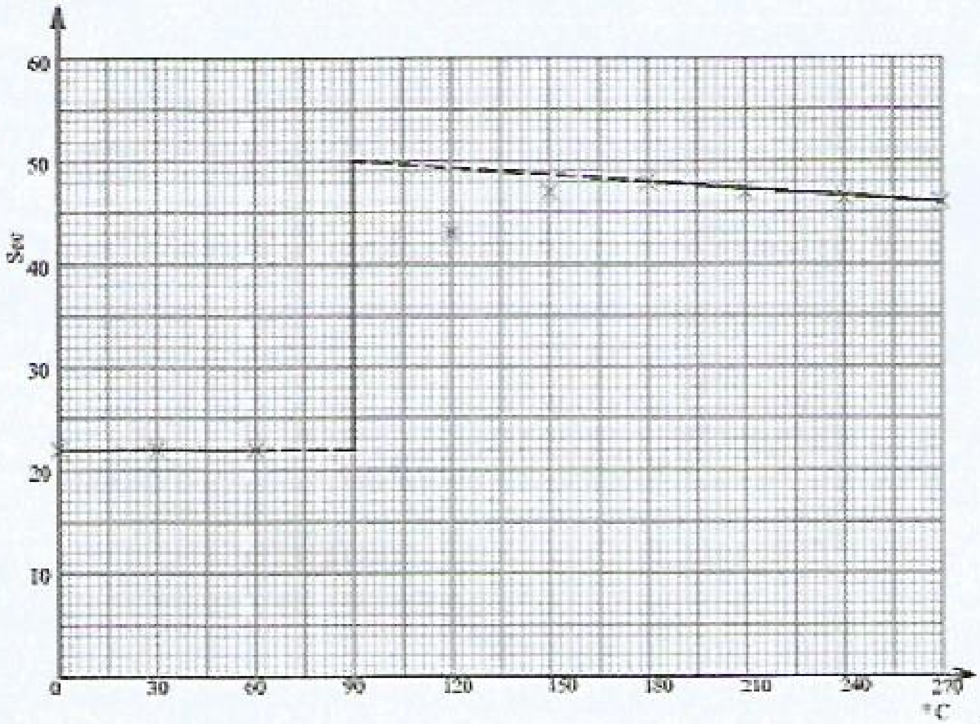
Expected Responses

Table 1

Time, s	0	30	60	90	120	150	180	210	240	270
Temperature, °C	22.0	22.0	22.0	X	43.0	47.5	48.0	47.0	46.5	46.0

- Complete table --(1 mark)
- Use of decimals (Either whole numbers, one decimal place as .0 , .5 ----(1 mark)
- Accuracy --($^1/_2$ mark)
- Trends - constant readings from t=0 sec to t=60sec, continuous rise in temperature readings from t=120 sec to maximum followed by a drop--($^1/_2$ mark)

a) Graph



- Scale---($^{1}/_{2}$ mark)
- Labeling of axes---($^{1}/_{2}$ mark)
- Plotting---(1 mark)
- Curve / lines --(1 mark)

b) On graph paper,

$\Delta T = (50.0 - 22.0)°C$✓½ $= 28.0°C$✓½

c) Heat change = 4.2 x 50 x 28.0 Joules✓[1]

= 5880 Joules✓[1]

d) Moles of magnesium $= \frac{0.30}{24} = 0.0125$

Enthalpy change, $\Delta H = \frac{-5880}{0.0125}$ x 1 J mol^{-1}✓½

= - 470400 J mol^{-1}✓½ **OR** - 470.4 kJ mol^{-1}✓

Table 2

	I	II	III
Final burette reading	24.80	33.50	41.50
Initial burette reading	1.00	10.00	18.00
Volume of Solution C used, cm^3	23.80	23.50	23.50

a) Average volume of solution C used

$$=\frac{23.50+23.50}{2}cm^3 ✓½$$

$= 23.50\ cm^3 ✓½$

b) (i) Moles of sodium carbonate $= \frac{0.15 \times average\ titre}{1000}$

$$= \frac{23.50\times0.15}{1000} ✓½$$

$= 3.525\times10^{-3} ✓½$

(ii) Reaction ratio is 1 mole Na_2CO_3 : 2 moles HCl

Moles of hydrochloric acid in $25.0cm^3$ = 2 × Answer in b(i)

$= 2\times3.525\times10^{-3} ✓½$

$= 7.05\times10^{-3} ✓½$

(iii) Moles of hydrochloric acid in $250\ cm^3 = \frac{\text{Answer in b(ii)} \times 250}{25}$

$10\times7.05\times10^{-3} ✓½$

$= 0.0705 ✓½$

(iv) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

Reaction ratio is Mg : HCl = 1 : 2

Moles of magnesium = 0.0125

Moles of hydrochloric acid = 2 x 0.0125✓½

= 0.025✓½

(v) Total number of moles of hydrochloric acid in $50\ cm^3$ of solution B

= Answer in b(iii) + answer in b(iv)

= 0.0705 + 0.025✓½

= 0.0955✓½

c) Concentration of hydrochloric acid in moles per litre of solution B

$$= \frac{\text{Answer in b(v)} \times 1000}{50}$$

$$= \frac{0.0955\times1000}{50} \text{ Moles per litre} ✓½$$

$= 1.91\ mol\ dm^{-3} ✓½$

Teachers should make use of inquiry based learning approach in the teaching of Chemistry. Emphasis should be on calculations, manipulation of apparatus and the use of correct scientific terms in reporting observations and inferences.

CONCLUSION

Chemistry as a subject was not performed well although there was some improvement. The practical which tests manipulative skills was the best with the mean standing at 36.1%. It is also worth noting that paper three does not test on drawing of structures which is largely dealt with in the theory paper. This means that in the inferences column, a candidate who infers using names should score full marks just as the candidate who infers using structures for example, if the inference is Iron (II) ions present / Fe^{2+} ions present both inferences are correct hence they should earn the same number of marks. Other examples include an unsaturated hydrocarbon /alkene/alkyne $>C=C<$ / $-C\equiv C-$ present, both names and structures are acceptable. Teachers should therefore avoid penalizing candidates when names of structures are used in recording inferences. Other examples include carbonate /CO_3^{2-} absent, sulphate/SO_4^{2-} present etc. Teachers of Chemistry should therefore do all they can to ensure that concepts, necessary skills and competencies are attained by the learners by the time they are sitting for their end of course examinations. This can easily be achieved by adopting the inquiry - based approach teaching the subject. Heads of Institutions, National, County and Sub-Counties should ensure that the laboratories are well equipped for teaching/learning and for examination purposes.