8.0 CHEMISTRY (233)

In the year 2006, Chemistry was tested using three papers. Unlike in the previous years, ***paper one (233/1)*** was marked out of 80 marks and tested the entire syllabus. It was also taken in two hours unlike in the previous years when it was taken in one and a half hours. ***Paper two (233/2)***, also a theory paper did not under go any changes in the format. ***Paper three (233/3)*** is a Practical paper taken in two and a quarter hours and marked out of 40 marks. Use of pipette fillers has been introduced as a precaution against poisoning during titration. The current syllabus also allows the use of volumetric flasks in the making of molar solutions.

8.1 GENERAL CANDIDATES' PERFORMANCE

The table below shows the performance in Chemistry during the year 2006 KCSE Chemistry examination.

Table 11: Candidates' Overall Performance in Chemistry in the Year 2006 KCSE Examination

Year	Paper	Candidature	Maximum Mark	Mean Score	Standard Deviation
2006	1		80	20.79	14.95
	2		80	17.56	13.82
	3		40	11.48	5.10
	Overall	**236,831**	**200**	**49.82**	**32.00**

Questions in which candidates performed poorly are discussed below.

8.2 PAPER 1 (233/1)

Question 6

In an experiment to study the properties of concentrated sulphuric acid, a mixture of the acid And wood charcoal was heated in a boiling tube.

(a) Write the equation of the reaction that took place in the boiling tube.

(b) Using oxidation numbers, show that reduction and oxidation reactions took place in the Boiling tube.

Candidates were required to recall the oxidation properties of concentrated sulphuric acid in a reaction with heated charcoal. They were also expected to write a balanced chemical reaction for a redox reaction between concentrated sulphuric acid and charcoal and use the equation to show that a redox reaction had occurred.

Weaknesses

Most candidates managed to write the correct equation for the reaction between heated carbon and concentrated sulphuric acid. However, some candidates did not know the products of the reaction. The candidates who seemed to know the products wrote the correct formulae of the reactants and products and hence had difficulties in balancing the equation. These weaknesses occurred because candidates were not exposed to experimental work. Students understand concepts in chemistry better when they are involved in carrying out experiments. Results of experiments should be discussed thoroughly between candidates and the teacher. Poor learners should be given remedial coaching in order to raise their level of understanding of the subject. It has been stressed before and will be repeated here that for equations to be acceptable, the formulae and symbols of the reactants and products must be correct and equations must be balanced and have the correct state symbols.

Concentrated sulphuric acid is a strong oxidizing agent. During reactions, it usually reduces to Sulphur dioxide and water is formed. Since generally oxidation - reduction processes take place simultaneously carbon would be oxidized to carbon dioxide. Therefore, it is possible to predict the products of the reaction even if they were not known. This calls for constant practice and thorough exposure to redox reactions.

Expected Responses

(a) $C_{(s)} + 2H_2SO_{4\,(l)} \_ CO_{2\,(g)} + 2H_2O_{(l)}$

(b) During the reaction, carbon changes from an oxidation of zero (0) to +4. Therefore, an increase in the oxidation state implies oxidation has occurred. Sulphur in sulphuric acid has an oxidation state of +6 but in the product ($S0_2$), it is at +4.

Question 16

When hydrogen sulphide gas was bubbled into an aqueous solution of iron (III) chloride, a yellow precipitate was deposited.

(a) State another observation that was made
(b) Write an equation for the reaction that took place.
(c) What type of reaction was undergone by hydrogen sulphide in this reaction?

Candidates were required to state the observations which would be made when hydrogen sulphide gas which is a reducing agent is bubbled into an aqueous solution of iron (III) chloride. They were also required to write an equation for the reaction between iron (III) chloride (aqueous) with hydrogen sulphide gas hence deduce whether an oxidation or reduction process had occurred.

Weaknesses

Candidates failed to state the correct observations that had been made. Others could not write equations hence were not able to deduce whether oxidation or reduction had occurred. The candidates' responses show that preparation of H_2S was not done and thus the properties of the gas were not properly learnt. Some wrong responses given by candidates included ***"A pale green precipitate was formed", "Hydrochloric acid was formed", "Colourless gas was evolved"*** and ***"White fumes were formed"***. Others did not attempt the question.

Though hydrogen sulphide is poisonous, it does not mean its properties cannot be studied. This can be done in a fume cupboard inside the laboratory with all windows open or the experiment can be conducted in the open. Most teachers are afraid of preparing such gases and this is quite unfair to the students as the practical aspect cannot therefore be tested. The syllabus says only theoretical treatment is allowed. The gas can however, be prepared in micro scale for its properties to be demonstrated. Innovation in sciences is very important.

Candidates should also think about the responses they write. Some of the candidates' responses were ***"Hydrochloric acid was formed"***. Even if it was formed, there was no way one would tell that it was HCL. The only observation would be a clear pale green solution formed. Once more, it is emphasised that equations should always be balanced.

Expected Responses

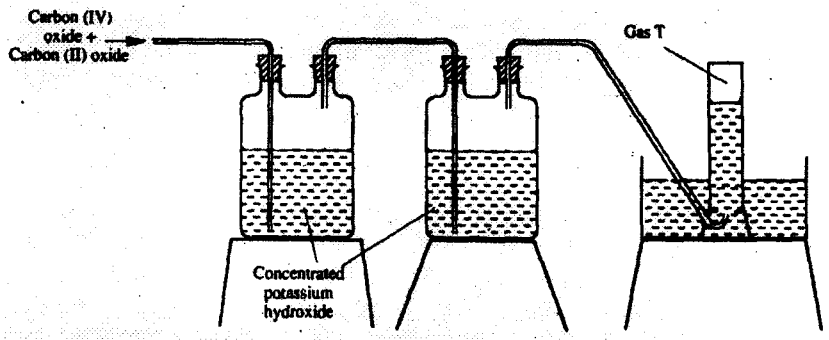
(a) Pale green solution was formed.

(b) 2Fe CL + H S

(c) Oxidation.

Question 22

The diagram below represents part of a set-up used to prepare and collect gas T.



(a) *Name **two** reagents that are reacted to produce both carbon (IV) oxide and carbon (II) oxide.*

(b) *Write the equation for the reaction which takes place in the wash bottles.*

(c) *Give a reason why carbon (II) oxide is not easily detected.*

In this question, candidates were expected to state two reagents which when reacted would give both Carbon (IV) oxide and Carbon (II) oxide. They were also expected to know the reactions which occur when acidic Carbon (IV) oxide is passed through basic Potassium Hydroxide and also the properties of Carbon (II) oxide.

Weaknesses

Majority of the candidates did not know that Carbon (IV) oxide is $C0_2$ and Carbon (II) oxide is CO hence they could not give the two reagents which when reacted produced both. Equations were poorly written and properties of carbon (II) oxide were not well understood.

The gas T being collected is Carbon (II) oxide. Like the case with H_2S, CO is poisonous. It can be prepared in the fume cupboard in small scale to demonstrate its properties. Teachers should change their methods of teaching from theoretical to experimental approach otherwise results in Chemistry will remain poor.

Expected Responses

(a) Oxalic acid and concentrated H_2SO4

(b) $2KOH_{(aq)} + CO_{2\,(g)} \rightarrow K_2CO_{3\,(aq)} + H_2O_{(1)}$

(c) CO is colourless, CO has no smell.

Question 23

Explain why the boiling point of ethanol is higher than that of hexane.
(Relative molecular mass of ethanol is 46 while that of hexane is 86).

In this question, candidates were expected to explain why the boiling point of ethanol whose relative molecular mass is 46 is higher than that of hexane whose relative molecular mass is 86.

Weaknesses

Candidates were not able to give a precise explanation as to why the boiling point of ethanol is

lower than that of hexane. Some irrelevant responses which were given by candidates included ***"Ethanol is a liquid in room temperature while hexane is a gas", "Ethanol is a giant structure while hexane is a simple molecular", "Ethanol has hydroxide bond while hexane has carbon bonds", "Because the boiling point of alkanols decreases down the group while that of alkanes increases"*** and ***"Covalent bonds in ethanol are stronger than those in hexane".*** Such responses show that the topic on hydrogen bonding had not been taught or had been taught poorly. The topic was tested for the first time in the year 2006 and it is possible that candidates were not expecting a question from this topic.

Generally melting and boiling of substances increases with increase in molecular mass. This is not the case. The difference is caused by the existence of hydrogen bonds in ethanol. These bonds do not exist in hexane. Hydrogen bonds are quite strong hence the boiling point of ethanol is higher than that of hexane. Candidates need to be thoroughly prepared in all topics. Test items can be picked from any section of the syllabus hence thorough preparation in all areas is necessary.

Expected Responses

In addition to Van der Waals forces of attraction, strong hydrogen bonds exist in ethanol. These bonds require more energy to break.

8.3 PAPER 2 (233/2)

Question 1

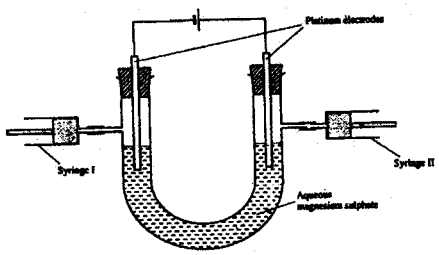
(a) What is an electrolyte?

(b) State how the following substances conduct electricity:

(i) molten calcium chloride

(ii) graphite

(c) The diagram below shows a set up that was used to electrolyse aqueous magnesium sulphate.



(i) On the diagram above, using an arrow, show the direction of flow of electrons.

(ii) Identify the syringe in which hydrogen gas would be collected. Explain.

(d) Explain why the concentration of magnesium sulphate was found to have increased at the end of the experiment

(e) During the electrolysis, a current of O.72A was passed through the electrolyte for 15 minutes. Calculate the volume of gas produced at the anode. (1 Faraday = 96 500 coulombs; molar gas volume is 24000 cm^3 at room temperature).

In this question, candidates were required to define an electrolyte, demonstrate an understanding on how metals and graphite conduct electric currents and name the products at the anode and cathode when $MgSO_{4(aq)}$ is fully electrolysed. The candidates were also required to state how the

concentration of aqueous Magnesium sulphate changes during electrolysis and calculate the volume of the gaseous product formed at the anode.

Weaknesses

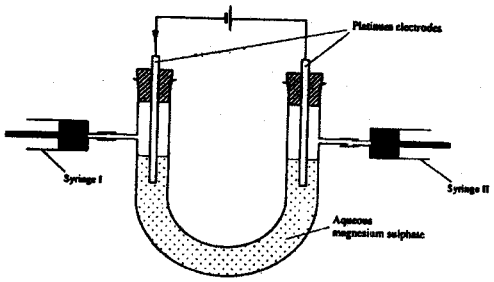
- Candidates failed to give the precise definition of an electrolyte. Some wrong responses given by candidates were ***"It is a substance that conducts an electric current', "It is a compound which conducts an electric current when in solution", "It is a solution containing ions"*** and ***"It is a substance which allows an electric current to pass"***
- Candidates were not able to state how molten Calcium Chloride conducts an electric current. Some wrong responses presented by candidates were ***"through electrolysis", "ions carry the current with it", "it is a good conductor of electricity"*** and ***"by using charged ions".*** From the responses given, it is clear that candidates had an idea about how Calcium Chloride (molten) conducts an electric current but were not able to communicate this in writing. In the case of $CaCl_2$, candidates were supposed to realize that it is an ionic substance. Ionic substances have mobile ions when in molten form and it is these mobile ions which conduct an electric current.
- Candidates were not able to give a reason for their choice of the syringe where hydrogen gas was collected. Perhaps this was through guessing, which should be avoided.
- Candidates were not able to explain why the concentration of Mg SO_4 increases during electrolysis. Indeed, many candidates were not able to score a mark. Some wrong responses given by candidates were ***"Mg So_4 was reduced to solid", "H+ ions which are acidic are introduced into solution"*** and ***"Mg^{2+} and SO_2^{2-} ions are being returned into solution".*** Others left the question unanswered. This kind of responses given by candidates show total lack of knowledge on the process of electrolysis of Mg $SO_{4(aq)}$. This could have been caused by poor tuition methods. Students should be allowed to carry out practicals in all topics. Clear observations should be recorded and these should be discussed thoroughly if performance in Chemistry is to be improved. Theoretical teaching in sciences should be avoided as much as possible.

Expected Responses

(a) A substance that allows the passage of an electric current and is decomposed by it.

(b) (i) $CaCl_2$ (molten) conducts an electric current because it has mobile ions.
(ii) Graphite conducts by movement of the delocalized electrons. (Notice electrons exist in substances but not all substances have delocalized electrons. This difference must be brought out clearly).

(c) (i)



(ii) The H+ ions migrate to the negatively charged electrode where they get discharged to form hydrogen gas.

(d) $4\ OH^-_{(aq)} \longrightarrow 2H_2\ 0(l) + O_{2\,(g)} + 4e$

$4H_2O_{(l)} \rightleftharpoons 4H^+_{(aq)} + 4OH^-_{(aq)}$

From the two equations, it is clear that 4 moles of water will be required to form 4 OH^- (first equation) hence the amount of water used to produce 4 OH^- ions is more than the 2 moles formed at the anode. Removal of water molecules makes the electrolyte more concentrated.

(e) Quantity of electricity 15 x 0.72 x 60 = 648 C

$4OH^- \longrightarrow 2H_2O + O_2 + 4e$

Faradays of electricity $\frac{648}{96500}$

$= 0.006715F$

Moles of Oxygen $\frac{0.006715}{4}$

$= 0.0016750$

Volume of Oxygen 0.001675 x 24000 = 40.29 cm^3

Question 2

(a) In an experiment to determine the molar heat of reaction when magnesium displaces Copper, 0.15g of magnesium powder were added to 25.0cm^3 of 2.0M copper (II) chloride solution. The temperature of copper (II) chloride solution was 25°C. while that of the mixture was 43°C.

(i) Other than increase in temperature, state and explain the observations which were made during the reaction

(ii) Calculate the heat change during the reaction (Specific heat capacity of the solution = 4.2$jg^{-1}K^{-1}$ and the density of the solution = Ig/cm^3).

(iii) Determine the molar heat of displacement of copper by magnesium. (Mg =24.0)

(iv) Write the ionic equation for the reaction.

(v) Sketch an energy level diagram for the reaction.

(b) Use the reduction potentials given below to explain why a solution containing copper ions should not be stored in a container made of zinc.

$Zn^{2+}_{(aq)} + 2e \rightarrow Zn_{(s)}$; $E^\theta = -0.76V$

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$; $E^\theta = +0.34V$

The question required the candidates to:

- State the observations made when solid magnesium is put into a solution containing CU^{2+} ions.
- Calculate the heat involved when some magnesium powder reacts with aqueous copper sulphate hence determine the molar heat of displacement of copper ions by Magnesium
- Write an ionic equation for the displacement reaction and draw an energy level diagram.
- State reasons why aqueous copper sulphate cannot be stored in a container made of zinc.

Weaknesses

- The average and below average candidates were not able to compute the molar heat of displacement.
- Some candidates could not write the ionic equation for the displacement reaction hence

they could not draw the energy level diagram. The weaknesses stated show that the topic was either not covered or was poorly covered using the lecture method. Head teachers are urged to allocate sufficient funds for purchase of equipment and chemicals for use during teaching and examinations. Theory papers will test everything from purely theoretical aspects to purely practical aspects of chemistry. Students should be adequately equipped in all aspects.

- Candidates were also not able to explain precisely why a solution containing copper ions should not be stored in container made of zinc. Some irrelevant responses presented by candidates were ***"Copper being a strong oxidizing agent will react with zinc'***, ***"Copper ions would be attracted by the negative zinc ions leading to formation of precipitate"*** and ***"Zinc can reduce copper solution to copper metal".***

The meanings of the sign and magnitude of the standard reduction potentials appear not to be well understood. The topic is rather abstract but if it is methodically approached using simple experiments, and examples the concept can be easily internalized. Zinc and copper are the substances used in batteries. When such batteries have been in use for sometime, they become soft. Students must have noticed this. This observation should have assisted candidates in answering the question. Concepts learnt must be linked to real life situations. This would make meaningful comparisons and arouse interest in the subject. In our case, Zinc has a negative potential, therefore, it must be more reactive than copper which has a positive reduction potential. If a solution containing CU^{2+} ions is put in a container made of Zinc, the Zinc would dissolve and disappear.

Expected Responses

(a) (i) The blue colour of the solution fades. (The colour is due to presents of CU^{2+} ions in solution. When these are removed by displacement, colour fades) Brown solid deposited (copper).

(ii) Heat change 25 x 4.2 x 18 = 1890 joules.

(iii)Mg Moles of Mg = $\frac{0.152}{24}$

$= 0.00625$

$0.00625M = 1890Joules$

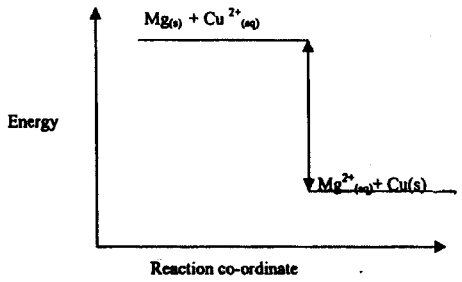
$1\ Mole = 1890/0.00625$

$= -303.4\ KJ\ mol^{-1}$

It should be noted that since the temperature of the reaction mixture went up, heat must have been released therefore the sign of the molar heat of displacement is negative.

(iv) $Mg_{(s)} + Cu^{2+}{}_{(aq)} \quad Mg^{2+}{}_{(aq)} + Cu_{(s)}$

(v)



(b) Zinc is higher than copper in the reactivity series or zinc is more reactive than copper. Zinc will thus dissolve in solution leading to weakening of the container.

8.4 PAPER 3 (233/3)

Question 2

*You are provided with solid **E**. Carry out the tests below. Write your observations and inferences in the spaces provided.*
*(a) Place about one third of solid **E** in a clean dry test-tube and heat it strongly.*
*(b) Place the remaining solid **E** in a boiling tube. Add about 10 cm^3 of distilled water. Shake the mixture thoroughly for about one minute. Filter and divide the filtrate into four portions.*
(i) To the first portion, add 2 drops of phenolpthalein indicator.
(ii) To the second portion, add 2 cm^3 of dilute hydrochloric acid.
(iii) To the third portion, add 5 cm' of aqueous sodium sulphate.

This question was on qualitative analysis where an unknown substance is given to candidates and they are expected to carry out experiments to find out its composition or functional groups present in it. The question tested on candidates' ability to select suitable apparatus for various tests, heat substances in test-tubes, make accurate observations and record them using acceptable scientific language and make accurate inferences based on the observations and report these using scientific language.

Weaknesses

Candidates did not take precautions when carrying out experiments hence the observations made were inaccurate. They were unable to make accurate inferences and communicate them using acceptable scientific language. Candidates are reminded that when carrying out experiments, suitable apparatus must be chosen.

Apparatus must be cleaned to avoid contamination and must be assembled correctly if accurate results are to be obtained. Accidents must be avoided as much as possible. Observations should be recorded as soon as they are made in order to avoid confusion later. Candidates are also informed that planning is very crucial before carrying out any experiment. Depending on the reagent being used, one can predict the results, for example: if aqueous sodium hydroxide is added to a colourless solution, one should expect either ***"A white precipitate"*** or ***"No White precipitate"***. On reporting, candidates should therefore write: "***White precipitate formed"*** or ***"No white precipitate"***. Candidates should avoid the use of phrases such as ***"No observation change"*** when they mean a precipitate was not formed. Also to be avoided are the use of terms such as ***"greenish", "yellowish"*** or "***brownish"*** when describing colour changes. Candidates should instead use terms such as "***pale-green", "light yellow"*** etc.

Inferences must also be written correctly. Formulae of ions, molecules, symbols or elements must be correct otherwise no mark will be given for wrong symbols or formulae, for example: ***"pb"*** instead of ***"Pb"***. Candidates must thus plan, carry out experiments cautiously, record observations correctly and then write inferences thoughtfully.

8.5 CONCLUSION

One of the demands in the 21st Century is the acquisition of scientific skills. Kenya cannot afford to be left behind. Teaching of Sciences, Chemistry included should therefore be enhanced in most schools. Laboratories must be constructed and properly equipped for teaching and examinations. The scientific approach is the method recommended worldwide for the teaching / learning of sciences. This not only provides the students with the necessary skills but makes the subject very interesting.