8.0 CHEMISTRY (233)

This was the fourth time the subject was tested using the revised curriculum. The subject is tested using two theory papers and one practical paper. Each theory paper is marked out of 80 marks and is taken in 2 hours. The practical paper is marked out of 40 marks and is taken in 2¼ hours.

8.1 CANDIDATES' GENERAL PERFORMANCE

Performance in 2006, 2007, 2008 and 2009 is shown in the table below:

Table 13: Candidates overall performance in Chemistry in the last four years.

Year	Paper	Candidature	Maximum Score	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**
2007	1		80	19.67	15.26
	2		80	19.22	13.45
	3		40	11.87	4.95
	Overall	**267,719**	**200**	**50.78**	**31.00**
2008	1		80	18.28	14.78
	2		80	15.74	13.00
	3		40	11.46	5.42
	Overall	**296,937**	**200**	**45.48**	**31.78**
2009	1		80	12.49	9.50
	2		80	14.93	12.04
	3		40	10.86	4.55
	Overall	**329,730**	200	38.23	24.53

From the table it is observed that:

8.1.1 The candidature for the subject increased from 296,937 in 2008 to 329,730 in 2009, a increase of 11%.

8.1.2 The mean for 233/1 dropped from 18.28 in 2008 to 12.49 in 2009. This was attributed to the candidates' inability to respond appropriately to questions that demanded application of knowledge.

8.1.3 The mean for 233/2 dropped slightly from 15.74 in 2008 to 14.93 in 2009.

8.1.4 The mean for 233/3 also dropped slightly from 11.46 in 2008 to 10.86 in 2009.

8.1.5 The overall mean dropped from 45.48 in 2008 to 38.23 in 2009, a drop attributed mainly to the poor performance in 233/1.

Questions which were poorly performed are discussed below:

8.2 PAPER 1 (233/1)

Question 3

The atomic number of sulphur is 16.

Write the electron arrangement of sulphur in the following:

(a) H_2S;

(b) SO_3^{2-}

In this question, candidates were expected to identify the number of electrons in sulphur in H_2S and SO_3^{2-} hence write the electron arrangement.

Weaknesses
Candidates failed to identify the number of electrons in sulphur in the molecule H_2S and in the radical SO_3^{2-} hence they could not write the correct electron arrangement.

The hydrogen ion usually has a positive charge of +1. Since there are two ions of hydrogen, the total positive charge is +2. H_2S is a neutral molecule. The charge on sulphur must be -2. Sulphur acquires this charge by gaining two electrons. Thus sulphur in H_2S must be having 18 electrons.

In the radical SO_3^{2-} out of a total of -6 charges contributed by oxygen, sulphur was able to neutralize only 4. Sulphur must have been at the oxidation state of +4. Sulphur acquires this oxidation state by losing 4 electrons. Since sulphur initially had 16 electrons, it must now be having 12 electrons.

These weaknesses are normally caused by poor coverage of syllabus. Teachers should endeavor to ensure that the meaning of the term oxidation number is well understood. Familiar examples e:g. Cr O_4^{2-} and $Cr_2O_7^{2-}$ should be used to explain this term. Candidates should also take time to understand the demands of a question before they begin to write their responses.

Expected Responses
(a) H_2S 2.8.8
(b) SO_3^{2-} 2.8.2

Question 11
Starting with 50 cm^3 of 2.8 M sodium hydroxide, describe how a sample of pure sodium sulphate crystals can be prepared. (3 marks)

In this question, candidates were required to describe an accurate step by step procedure which can be used to prepare a pure sample of sodium sulphate crystals starting with 50 cm^3 of sodium hydroxide whose concentration is known.

Weaknesses
The candidates could not correctly determine the volume and concentration of sulphuric acid required in order to make a neutral solution. Since they could not make a correct start all other steps whether correct or wrong could not earn marks.

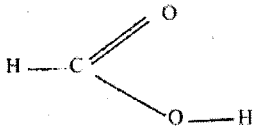
Once more, candidates should read the question carefully and thoughtfully, give it the correct interpretation and then plan on how to proceed in answering it. Questions on preparation of salts require careful step by step procedures. The starting point is very important, if the start is wrong, then the whole procedure is unacceptable and all the marks are lost.

Teachers should expose students to different methods of preparing salts and emphasize on the precautions to be taken in order to achieve the desired salt.

Expected Responses
To 50 cm^3 of 2.8 M sodium hydroxide, add 25 cm^3 of 2.8 M H_2SO_4 or 50 cm^3 of 1.4 M of H_2SO_4 in order to prepare a neutral solution of sodium sulphate. Heat the mixture to concentrate it. Cool it for crystals to form, filter and dry the crystals.

Question 17

The structure of methanoic acid is



What is the total number of electrons used for bonding in a molecule of methanoic acid? Give reasons.

In this question the candidates were required to state the number of electrons used in bonding in a molecule of methanoic acid.

Weaknesses
Majority of the candidates did not know that a single covalent bond is made up of two electrons. This kind of weakness is probably caused by poor teaching. Students learn how a single covalent bond between two hydrogen atoms is formed by sharing two electrons. Models should be used to illustrate bonding in various molecules and a deliberate effort made to show and differentiate between a single, double and triple covalent bonds.

Expected Response
10 electrons
There are three single bonds each consisting of 2 electrons and one double bond consisting of 4 electrons.

Question 24
The boiling points of some compounds of hydrogen with some elements in Groups 4 and 6 of the periodic table are given below.

Compound	Boiling point (°C)	Compound	Boiling point (°C)
CH_4	-164.0	H_2O	100.0
SiH_4	-112.0	H_2S	-61.0

(a) Which of the compounds CH_4 and SiH_4 has the stronger intermolecular forces?
(d) Explain why the boiling points of H_2O and H_2S show different trends from that of CH_4 and SiH_4.

In this question, candidates were required to:

(a) Compare the boiling points of CH_4 and S_1H_4 and determine which of the two has the stronger intermolecular force of attraction.
(b) Explain why the boiling points of H_2O and H_2S are higher than those of CH_4 and S_1H_4.

Weaknesses
- Candidates did not know that the boiling point -112^0C is higher than -116^0C. Boiling points are a reflection of the strengths of the intermolecular forces of attraction between molecules. In our case, S_1H_4 with a boiling point of -112^0C has a stronger molecular force of attraction hence requiring more energy to break.
- Candidates did not seem to realize that H_2O and H_2S have much higher boiling points compared to CH_4 and S_1H_4. The fact that they have higher boiling points indicate that a different type of bonding exists in them. Both H_2O and H_2S are capable of forming hydrogen bonds. Hydrogen bonds are much stronger than intermolecular forces of attraction and thus require more energy to break them.

The weaknesses shown indicate that the topic is poorly understood by majority of the candidates. Teachers should allocate more time on difficult topics to ensure that the concepts are well understood. More practice is required on questions which show how different types of bonding affect the physical properties of substances. Students with difficulties in understanding these topics should be identified and remedial teaching arranged in order to lift their knowledge of such difficult topics.

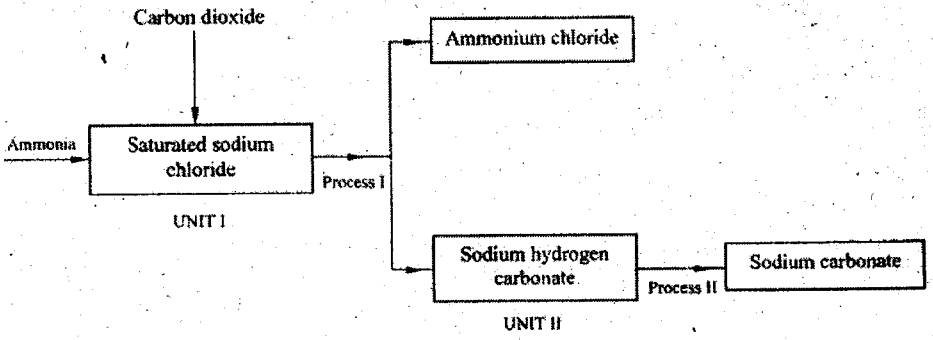
Expected Responses
(a) S_1H_4, it has a higher boiling point.
(b) No hydrogen bonding in CH_4 and S_1H_4 and that the hydrogen bond in H_2O is stronger than that in H_2S.

8.3 PAPER 2 (233/2)

The most poorly performed questions in this paper were questions 4 and 5. These questions are discussed below:

Question 4

(a) The schematic diagram shows part of the Solvay process used for the manufacture of Sodium carbonate.



(i) Explain how the sodium chloride required for this process is obtained from sea water.

(ii) Two main reactions take place in UNIT 1. The first one is the formation of ammonium hydrogen carbonate.
I. Write an equation for this reaction
II. Write an equation for the second reaction

(iii) State how the following are carried out:
I. Process I
II. Process II

(iv) In an experiment to determine the percentage purity of the sample of sodium Carbonate produced in the Solvay process, 2.15 g of the sample reacted completely with 40.0 cm^3 of 0.5 M sulphuric acid.
I. calculate the number of moles of sodium, carbonate that reacted.
II. Determine the percentage of sodium carbonate in the sample.
(Na = 23.0, C = 12.0, O = 16.0)

(b) Name two industrial uses of sodium carbonate (2 marks)

The question required the candidates to:

- Explain how sodium chloride is extracted from sea water.
- Write equations for the reactions which produce ammonium hydrogen carbonate and sodium hydrogen carbonate in the Solvay process.
- Show how ammonium chloride is separated from sodium hydrogen carbonate.
- Determine the percentage of sodium carbonate in the sample obtained.
- State the uses of sodium carbonate.

Weaknesses

- Candidates were not able to recall the method used to extract sodium chloride from sea water. Those who had an idea did not describe the process properly and therefore lost marks.
- The average and below average candidates were not able to write the correct equations for the reactions in which ammonium hydrogen carbonate and sodium hydrogen carbonate are produced.

The kind of weaknesses stated may have occurred due to teaching which is not exhaustive enough. **Students** and teachers advised that no topic of the set syllabus is exempted from examining. **All** topics should therefore be given **thorough** coverage during teaching/learning process.

Students are also reminded not to rely on past papers alone. Past papers will generally give an idea of the language used in testing a subject but not the questions that are likely to be set. The questions in the paper will be original and candidates need to be thoroughly prepared.
One of the goals of teaching chemistry is to be able to utilize resources in our environment to obtain goods. Sodium chloride is one of such goods and candidates should have known how it is obtained from the sea water. Equations should always be balanced and have the correct state symbols.

The questions that dealt with separation of mixtures, calculations based on mole concept and the uses of sodium carbonate were well performed.

Expected Responses

4. (a) (i) Pump sea water to shallow ponds, evaporation of H_2O takes place, leaving NaCl to crystallize out .

(ii) I $NH_3(g) + CO_{2\,(g)} + H_2O_{(l)} \longrightarrow NH_4HCO_{3\,(aq)}$

II $NH_4HCO_{3\,(aq)} + NaCl_{\,(aq)} \longrightarrow NaHCO_{3\,(s)} + NH_4Cl_{\,(aq)}$

(iii) I Filtration

II Heating

(iv) I $Na_2CO_{3\,(s)} + H_2SO_{4\,(aq)} \longrightarrow Na_2SO_{4\,(aq)} + CO_{2\,(g)} + H_2O_{\,(l)}$

$$\text{Moles of } H_2SO_4 = \frac{40 \times 0.5}{1000} = 0.02$$

Moles of $Na_2CO_3 = 0.02$

II Mass of $Na_2CO_3 = 0.02 \times 106 = 2.12_{\,g}$

$$\% \text{ purity} = \frac{2.12}{2.15} \times 100 = 98.6\%$$

(b)
- Glass making
- Softening water
- Detergent
- anti-acid
- Paper industry etc

Question 5

(a) **Figure 3** shows the changes that take place between states of matter. Some of them have been Identified and others labelled.

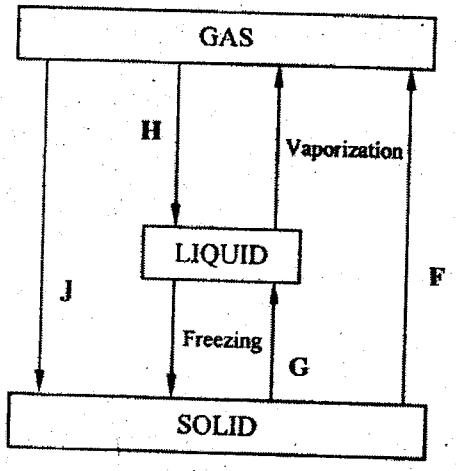


Figure 3

(i) Give the names of the processes

I. **H**

II. **G**

(ii) Name **one** substance that can undergo process **F** when left in an open container in the laboratory.

(iii) The process **J** is called deposition. Using water as an example, write an equation that represents the process of deposition.

(b) **Figure 4** shows the heating curve for water.

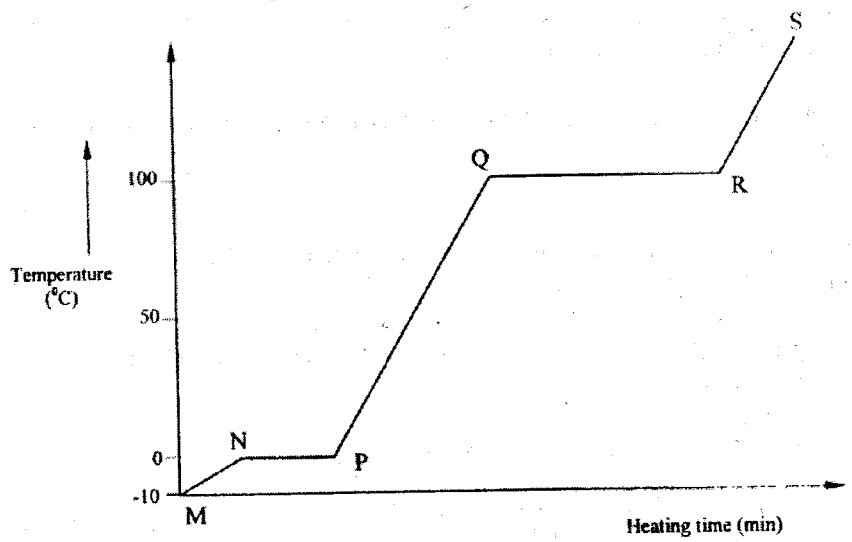


Figure 4

(i) Give the names of the intermolecular forces of attraction in the segments:
I **MN**
II **RS**

(ii) The heats of fusion and vaporization of water are 334.4 Jg^{-1} and 1159.4 Jg^{-1} respectively.
I Explain why there is a bit difference between the two
II How is the difference reflected in the curve?

(c) Coal, oil and natural gas are major sources of energy. They are known as fossil fuels. Hydrogen is also a source of energy.
(i) state and explain **two** reasons why hydrogen is a very attractive fuel compared to fossil fuels.
(ii) State **one** disadvantage of using hydrogen fuel instead of fossil fuels.

(a) The question required the candidates to study a diagram on changes that take place between states of matter and name specific processes.
(b) Use the heating for water to show understanding of:
- Intermolecular forces of attraction
- Heats of fusion of water and vaporization and explain their differences

(c) Give reasons why hydrogen is a better fuel than fossil fuels
(d) State why use of hydrogen is not encouraged.

Weaknesses
Candidates performed quite well in parts a(i), (ii), (iii) and part b(i). However they could not:
- Explain why there is a big difference between heat of fusion and heat of vaporization.
- State two reasons why hydrogen is a better fuel compared to fossil fuels.
- They also could not state why using hydrogen is more dangerous than using fossil fuels.

The first weakness is likely to have been caused by use of theoretical teaching as opposed to practical approach. Students should be allowed to carry out experiments to determine the heating/cooling curves of simple substances like water and naphthalene. Detailed explanations of the distinct areas/segments of the curves should

be discussed thoroughly. Questions on such curves for other substances can be given as exercises. The responses are marked and discussed. This enhances the understanding of the topic.

Sources of different fuels, their advantages and disadvantages should be well discussed with particular reference to environmental pollution, cost and any possible dangers they pose.

Expected Responses

(a) (i) I Condensation
II Melting
(ii) Iodine/ benzoic acid/ Naphthlene/ solid ice/ dry ice
(iii) $H_2O_{(g)} \longrightarrow H_2O_{(s)}$

(b) (i) I Van der waals and hydrogen bonding
II Van der waals forces
(ii) I In melting energy is used to overcome the hydrogen bonds and Van der waals forces of attraction.
But during vaporization, extra energy is required to move the molecules away from one-another
II QR is larger than NP

(c) (i) Hydrogen when burned produces H_2O which is a non-pollutant
Has high energy content. Small amount of hydrogen produces a lot of heat
H_2 is a renewable energy - so it cannot be exhausted.
(ii) It can easily explode when burning
OR
High cost of production/ it is expensive

8.4 PAPER 3 (233/3)

1 You are provided with:

- solid **A**, a metal carbonate M_2CO_3
- solution **B**, hydrochloric acid **for use in Questions 1 and 2**
- solution **C**, 0.30M sodium hydroxide
- methyl orange indicator.

You are required to:

- prepare a dilute solution of hydrochloric acid and determine its concentration;
- determine the solubility of solid **A** in water.

Procedure:

(Reserve one **dry** conical flask for use in step 4).

Step 1 Place all of solid **A** in a 250 ml **dry** beaker. Add 100 cm^3 of distilled water to solid **A** in the beaker. Using a glass rod, stir the mixture thoroughly for about two minutes. Leave the mixture to stand and proceed with steps 2 and 3.

Step 2 Using a pipette and a **pipette filler**, place 25.0cm^3 of solution **B** in a 250 ml volumetric flask. Add about 200cm^3 of distilled water. Shake the mixture well and add distilled water to make up to the mark. Label this as solution **D**.

Step 3 Fill a burette with solution **C**. Using a pipette and a **pipette filler**, place 25.0cm^3 of solution **D** into a 250ml conical flask. Add two drops of the indicator provided and titrate solution **D** with solution **C**. Record your results in Table 1. Repeat the titration two more times and complete Table 1. **Retain** the remaining solution **D** for use in step 5.

Step 4 Filter the mixture obtained in step 1 using a **dry** filter funnel into a **dry** conical flask. Label the filtrate as solution **A**.

Step 5 Clean the burette and fill it with solution **D**. Using a pipette and **a pipette filler**, place 25.0cm^3 of solution **A** into a 250ml conical flask. Add two drops of the indicator provided and titrate solution **A** with solution **D**. Record your results in Table 2. Repeat the titration two more times and complete Table 2.

Table 1

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

(a) Calculate:
- (i) averge volume of solution **C** used
- (ii) moles of sodium hydroxide in the average volume of solution **C** used
- (iii) moles of hydrochloric acid in 25.0cm^3 of solution **D**.
- (iv) the molarity of hydrochloric acid, solution D

Table 2

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

(b) Calculate:
- (i) average volume of solution **D** used
- (ii) moles of hydrochloric acid in the average volume of solution **D** used
- (iii) moles of the metal carbonate, solid A in 25.0cm^3 of solution **A**
- (iv) the solubility of the metal carbonate, solid **A** in water.
  (Relative forcular mass of metal carbonate = 74, assume density of solution = 1g/cm^3)

In this question, the candidates were required to use a described procedure in order to:
(a) Prepare a dilute solution of hydrochloric acid and determine its concentration.
(b) Use the diluted hydrochloric acid whose concentration has been determined to find the solubility of a metal carbonate M_2CO_3.

Weaknesses

Most of the candidates were able to use the correct apparatus to prepare the diluted hydrochloric acid, carry out titrations as per the instructions and record the results correctly in the correct tables. Though the results obtained were accurate, few candidates were not able to apply their knowledge on mole concept in order to calculate the concentration of the dilute hydrochloric acid, hence the solubility of the metal carbonate M_2CO_3.

For many years, the mole concept has been a problem to many candidates

Teachers should set aside adequate time for practicals in quantitative analysis. They should use past papers as examples as well as practicals described in standard text books. Each student should be allowed to carry out the exercises individually. Results of the practical lessons should be discussed immediately.

More questions based on the mole concept should then be given. Individual areas of weaknesses should be identified and the candidates given remedial teaching.

Question 2

You are provided with solid **E**. Carry out the following tests and write your observations and inferences in the spaces provided.

(a) Place about one-half of solid **E** in a dry test-tube. Heat it strongly and test any gas produced using hydrochloric acid, solution **B** on a glass rod.

Observations	Inferences
(2 marks)	(1 mark)

(b) Place the rest of solid **E** in a boiling tube. Add about $10cm^3$ of distilled water. Shake well and use $2cm^3$ portions for each of the tests below.

(i) To one portion, add aqueous ammonia dropwise until in excess.

Observations	Inferences
(1 mark)	(1 mark)

(ii) To a second portion, add about $1cm^3$ of hydrochloric acid, solution **B**.

Observations	Inferences
(1 mark)	(2 marks)

(iii) To a third portion, add two drops of aqueous lead (II) nitrate and heat the mixture to boiling.

Observations	Inferences
(1 mark)	(1 mark)

Question 2 was on qualitative analysis. The candidates were required to:

- Carry out described tests;
- Write correct observations using scientific language;
- Draw logical conclusions from the observations made.

Weaknesses

- Candidates failed to write the correct observations using acceptable scientific language.
- They also failed to draw logical inferences from the observations.

The weaknesses stated above are likely to have been caused by lack of exposure to practical work during teaching/learning process.

Students should be allowed to use simple apparatus and chemicals to carry out experiments **individually** during learning. This is the only way they would master the psychomotor skills tested during practical examinations.

They should be encouraged to use **all** necessary precautions in order to obtain accurate observations and use correct descriptions of the observations e.g. question 2(a), on heating solid E one of the observations was 'a colourless liquid forms on the cooler part of the test tube'. But many candidates wrote 'water forms on the cooler part of the test tube!

Once more, teachers and students are reminded that unless the observations are accurate and are correctly described, the inference **cannot** be correct and therefore **all** the marks are lost.

Candidates also lost marks because they could not draw logical inferences e.g. Question 2b(i), they were asked to add aqueous ammonia dropwise until in excess to a solution of Solid **E** in water. Candidates should know that aqueous ammonia is used to primarily show the presence or absence of Zn^{2+}, Pb^{2+} or Al^{3+} ions depending on the observations. In this case a white ppt was formed. The ppt did not dissolve in excess. The only logical inference was Pb^{2+} or Al^{3+} present or Zn^{2+} Absent. Some candidates knew the correct inference but did not write the correct formula of the ion. It is important to write the correct formula of ions e.g. Al^{3+} and not AL^{3+}.

In question 2b(ii) candidates were asked to add 1 cm^3 of dilute hydrochloric acid to a solution of **E** in water. In this case the correct observations were:

(i) No white ppt formed
(ii) No effervescence

The fact that there was no white ppt can only mean that the cation in solid **E** cannot be Pb^{2+}. It can only be Al^{3+} because $AlCl_3$ is soluble. Al^{3+} had been implied in question 2b(i). Candidates who infered presence of Mg^{2+} Ca^{2+} etc had not connected the observations and inferences in question 2b(i) to those in question 2b(ii). Also the fact that there was no effervescence meant that the anion in solid **E** cannot be CO_3^{2-} or SO_3^{2-}. It could be a SO_4^{2-}

Expected Responses

	Observations	Inferences
2. (a)	• a colourless liquid condenses on the cooler parts of the test tube	Hydrated salt/compound
	• Gas produced forms white fumes with HCl	ammonia
b (i)	White ppt insoluble in excess	Pb^{2+} or Al^{3+}
(ii)	No white ppt	Pb^{2+} Absent or Al^{3+} Present
	No effervescence	CO_3^{2-} - Absent
(iii)	White ppt	SO_4^{2-} - Present

8.5 ADVICE TO TEACHERS

It is necessary for teachers of science to use the practical approach mthod during teaching and learning. Students should be allowed to experiment, discover and develop creative critical thinking skills required in the education system. Schools should provide adequate equipment and chemicals for use during teaching and practical examinations. It is unfair for candidates to see some apparatus for the first time during examinations.

All topics should be given thorough evaluation. Students with particular weaknesses should be identified early enough. Remedial teaching should be arranged and carefully executed if good results are to be expected.