CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE SECONDARY EDUCATION CERTIFICATE EXAMINATION

JANUARY 2012

CHEMISTRY
GENERAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

Overall, candidates' performance in this sitting of the examination declined compared with performance in 2011. There were some common areas on both Papers 01 and 02 that were challenging for the candidates. Additionally, gaps were apparent in candidates' understanding of concepts and this was evident in poor responses in several cases.

Candidates exhibited strengths in:

- reading scales of the instruments drawn
- plotting of points accurately, given axes.

However, they demonstrated weaknesses in the following areas:

- Depth in Responses Provided

Vague and incomplete responses were significant contributory factors to candidates' overall poor performance on the written papers. Candidates tended to be superficial− giving only parts of the required responses − they failed to provide adequate explanations or evidence for proposed claims. This led to very few cases in which full marks were awarded for questions or sections of questions.

- Writing and Balancing Equations

The ability to write balanced equations based on interpretation of reactions described as well as to recall common reactions was tested in several questions. The responses in this area were generally weak. The main deficiencies identified were:

- omission of or incorrect state symbols in ionic equations
- wrong products for reactions that ought to be known based on the syllabus requirements
- failure to balance equations, including balancing charge for ionic equations
- writing chemical formulae.

- Defining and Discriminating among Concepts

Critical information was often omitted from definitions of concepts.

The point made in a previous report is worth repeating here. Candidates confuse concepts and principles that seem to be related in some way and fail to make distinctions regarding why some reactions take place while others do not. For example, candidates know the group trends in terms of reactivity for the groups. However, they fail to discriminate between how metals versus non-metals react. This was clearly seen in response to Question 4.

- Unfamiliarity with Procedures

It was evident that there was limited recollection and understanding of some common practical procedures such as testing for gases, identifying reducing and oxidizing agents, and determining the heat of solution. In many instances, essential steps were omitted or predicted results were incorrect.

Generally, it appears that candidates need more practice in writing ionic and molecular equations. This is likely to be more meaningful if the equations are linked to actual observations of chemical reactions where the association can be made between the observations, the use of the symbolic language of chemistry and the activities at the molecular level. Candidates are also encouraged to provide more specific and detailed explanations which show a deeper understanding of the processes occurring at the molecular level.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. Performance on this paper continued to be consistent with the performance of the last two years. The mean score earned by candidates was 52 per cent, with a standard deviation of 11.

Paper 02 – Structured/Extended Response Questions

Question 1

Syllabus References: A: 6.14, 6.15, 6.16, 6.17, 8.1, 8.2, 8.3

The mean score for this question was 7 out of 25.

In Part (a), candidates were required to define *heat of neutralization* and to use titration data to construct a graph and determine the heat of neutralization. Candidates failed to include critical components in the definition such as *the reaction between an acid and a base* and *the production of 1 mole of water*, which resulted in several of them obtaining only one of the two marks for definition. Many candidates did not know the definition and attempted to describe the reaction for determining the heat of neutralization. A few candidates described heat of neutralization in terms of a temperature change instead of the heat produced for the reaction. Such responses included ‘the temperature change during a neutralization reaction or the heat taken to neutralize a solution’. Neither of these responses was awarded a mark.

Responses such as *the heat of neutralization is the energy change per mole of water during the neutralization reaction between an acid and a base* were awarded full marks as they reflected an understanding of a neutralization reaction and associated the heat change with the number of moles of water produced.

The majority of candidates was able to plot the graph using the given data but some failed to interpret the scale correctly and lost marks. Part (a) (ii) required the use of the graph to determine the end point of the reaction. Most candidates knew that the end point should be determined from the intersection of the ascending and descending lines on the graph. A few candidates plotted the points but failed to draw the lines and so failed to earn the mark for Part (a) (ii). For the most part, those who drew straight lines drew the best straight lines. A few candidates drew curves which ought not to have been the case for a graph showing heat of neutralization.

The calculation in Parts (a) (iii) and (iv) were fairly well done and candidates were able to obtain some of the marks for this section. The weaknesses in the responses to Parts (a) (iii) and (a) (iv) were:

- including the term ‘neutralization’ in the definition for heat of neutralization without explaining that this refers to a reaction between an acid and a base
- failing to add the mass of the acid and base
- failing to convert the mass from grams to kilograms.

Calculation of Heat Change at the Point of Neutralization

Volume of Acid from graph = 12 cm^3
Total volume of liquid: 12 cm^3 + 25 cm^3 = 37 cm^3
Mass = 37 g = 0.037 kg
ΔH = $0.037 \times 4.2 \times 18$
= 2.8 kJ

Part (b) tested candidates' knowledge of the laboratory experiment to determine the heat of solution of potassium nitrate and their ability to draw a suitable energy profile diagram.

In Parts (b) (i) and b (ii), very few candidates provided a suitable definition of the heat of solution. Many candidates used some concepts incorrectly or did not complete the responses. Many of them knew that making a solution involves the solute dissolving in the solvent. However, the majority of them failed to include the amount of solute (1 mole) in the definition. Hence, vague responses such as "the heat produced when a substance is allowed to dissolve in water or heat taken in by a solution" were awarded no marks. Neither of these addressed the amount of solute or formation of a solution from a solute and a solvent.

However, responses such as *energy change in which 1 g of solute dissolves in a particular volume of solvent to form a solution* were awarded one mark while *the heat of solution is the energy change when 1 mole of solute completely dissolves in a particular volume of solvent* was awarded two marks. Almost all the candidates were able to read the scales in Figure 2.

In Part (b) (iii), weak experimental skills and lack of procedural knowledge for determining the heat of solution were evident in candidates' responses. Given that the required procedure involved measuring temperature change, it was important that candidates included the use of insulated containers, measured the amount of water and the KNO_3, recorded the temperature of the water before mixing with the KNO_3, and recorded the final temperature given that the reaction was endothermic. It was also important that the correct sequence of steps was carried out for the reaction. Some of the more common incorrect steps are noted here.

- Omitting to weigh potassium nitrate and measure the volume of water
- Carrying out the experiment in a beaker instead of an insulated container
- Measuring the initial temperature as that after the solute was added to the solvent instead of the temperature of the water before adding the salt
- Describing the procedure for a titration to find heat of solution
- Suggesting that the 'highest temperature' instead of the *final temperature* should be measured although the reaction was endothermic
- Failing to identify the reaction as endothermic. This also led to incorrect energy profile diagrams in Part (iv).

A *good* response by a candidate which was awarded full marks is indicated below.

1. Weigh the amount of solid needed (8 g KNO_3) using an electric balance.

2. Measure 50 $cm^3$of water using a measuring cylinder.

3. Empty water in a polystyrene cup, insert a thermometer and record the reading when the temperature is constant.

4. Mix the 8 g of KNO_3 in the water and stir vigorously using the thermometer.

5. Record the final temperature when the reading is constant.

In Part (b) (iv), many candidates either failed to recognize the reaction as endothermic or did not recall the energy profile diagram for an endothermic reaction. Hence, some candidates drew the energy profile diagram for an exothermic reaction. A fair number of candidates were either unprepared for this part of the question or misinterpreted the question and drew the apparatus for conducting the reaction. In most instances, candidates lost marks for incorrectly labelling the axes as ‘temperature’ and ‘time’ instead of *energy* and *reaction pathway*.

Marks were awarded for a diagram with the correct shape for an endothermic reaction, correct labelling of the axes and correct identification of the heat of reaction or the activation energy. Both axes had to be correctly labelled in order to be awarded full marks.

Part (c) tested candidates’ ability to identify reducing and oxidizing agents based on observed experimental data and to write balanced half equations to show oxidation of iron(II) nitrate. Overall, the performance of candidates on this section of the paper was poor. The majority exhibited significant challenges in writing balanced chemical equations, in particular, those that represent redox reactions. In most cases, their equations were incorrect as charges and/or atoms were not balanced. This section also drew on candidates’ familiarity with practical procedures, such as conducting tests using specific oxidizing and reducing agents (Syllabus Objectives A:6.16 and 6.17). The responses suggested that there was a general lack of knowledge in this area which may be due to limited exposure to practical work.

Very few candidates were able to describe the expected observation for Experiment 3. This reaction was confused with the reaction between Pb^{2+} ions and aqueous potassium iodide. Hence, many candidates reported a yellow precipitate as the expected result. This response was not awarded any marks. Based on Table 2, the colour changes indicated that iron(II) nitrate was oxidized and potassium magnate(VII) reduced. Hence X was both an oxidizing and a reducing agent.

The correct half equation for the reaction with aqueous iron(II) nitrate required inclusion of state symbols. Teachers and candidates are reminded that state symbols are always required for ionic equations. The correct equation for Part (c) (i) is given below.

$$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^{-}$$

The correct response for Part (c) (iii) was a *brown precipitate*. Marks were also awarded for ‘brown solution’.

Some common *errors* and *incorrect* responses are noted below:

- Confusion of what happens to the oxidizing and reducing agents versus the oxidized and reduced species in a redox reaction. Several candidates reported that Fe^{2+} was reduced to Fe^{3+}.
- Failure to explain why oxidation or reduction occurred in the case of Fe^{2+} and MnO_4^- respectively. Although some candidates were able to correctly identify Fe^{2+} as being oxidized and MnO_4^- as being reduced, they were unable to explain why this was so using oxidation numbers.
- There was an unawareness that some substances can function both as oxidizing and reducing agents.
- The e^- in the half equation was either missing or misplaced in many cases.
- There seemed to be greater familiarity with the reactions of potassium permanganate as an oxidizing agent than with Fe^{2+} as a reducing agent.

Question 2

Syllabus References: A: 3.2, 3.3, 3.4, 4.5, 4.7, 7.1, 7.2, 7.3

Parts (a) to (c) tested candidates’ knowledge of factors that affect the rate of reaction of hydrochloric acid on calcium carbonate. They were also required to interpret graphical data to calculate the mass of calcium carbonate used in the reaction. Part (d) tested candidates’ knowledge of conductivity of ionic crystals.

The average mark on this question was 6 out of 15, with candidates scoring the complete range of marks, 0 to 15.

For Parts (a) and (b), almost all candidates were able to write the correct equation for the reaction between calcium carbonate and dilute hydrochloric acid. A few candidates had problems balancing equations even though this reaction has been tested on several occasions.

Most candidates correctly interpreted Figure 3 and gave the total volume of gas as 20 cm^3. There were a few instances where candidates were unable to interpret the graph and added the volume of gas produced at 1, 2, 3, 4, 5 and 6 minutes to obtain the total volume of gas produced.

The calculation of the number of moles of gas at STP as well as the mass of limestone proved relatively simple for the more able candidates. The weaker candidates tended to multiply the volume of gas by 22, 400 instead of dividing to obtain the number of moles of gas.

Generally, for Part (c), candidates were able to explain the rate of reaction and to identify two factors that affect the rate of reaction. However, factors were suggested which would not be relevant for this specific reaction (acid + carbonate), such as light, pressure and catalyst.

Almost all candidates correctly inferred that increasing the temperature would increase the rate of reaction. However, here again, the explanations for the increase in rate were vague and incomplete. These included responses such as “particles move faster at a higher temperature” or “particles have more energy”.

The correct response required an explanation in terms of the effect of an increase in kinetic energy. As such an expected response was

> *Increase in temperature causes particles to move faster resulting in more collisions of particles with minimum energy to react.*

Part (d) required the conditions for conduction in ionic compounds and the reasons for these. These were not fully understood by the majority of candidates. Many had the general understanding that charged particles are necessary for conducting electric current but there was not enough discrimination in terms of which particles are responsible for conduction in ionic compounds versus metals and the reason why conduction is not possible in ionic crystals even though ions are present. This was evident in *incorrect* responses such as:

- *Calcium carbonate will not conduct electricity in the solid state as it is not a metal and only graphite and metals conduct in the solid state*.
- *It will not conduct because no free or mobile electrons are present*.
- *It will not conduct because ionic compounds only conduct when liquid or molten*.

The *correct* response was:

> *The ions of solid calcium carbonate are fixed within the lattice and there are no mobile ions to carry the current*.

<u>Question 3</u>

Syllabus References: B1: 3.1, 3.2, 3.5, 4.4, 4.5, 4.6, 4.7

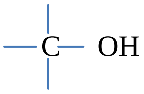
Candidates were tested on the fractional distillation of crude oil, nomenclature and structure of esters and the structure and properties of polymers. The average mark on this question was 4 out of 15, with a significant number of candidates unable to score 8 or more marks. Too many candidates continue to perform poorly on organic chemistry.

For Parts (a) and (b), most candidates were able to obtain some of the marks for naming two sources of hydrocarbons. The most common responses were *petroleum and crude oil*. Only a few candidates named *peat, natural gas* and *coal* as other sources.

Most candidates were able to give the name of a fraction from the distillation of crude oil and give one use for one fraction. Some candidates lost marks for stating names of fractions such as 'kerosene' instead of giving its use.

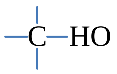
In Part (c), the majority of candidates were unable to identify Compound X as *ethyl ethanoate* although many knew that it was an ester. Drawing the correct structures for the hydrolysis products of the ester was also challenging for many candidates. They named a range of organic products and many did not attempt to draw the compounds. Many candidates are still not paying attention to important details, for example, the valences of oxygen and carbon, when they draw the structures of organic compounds. A common error made with the structural formula of hydroxyl compounds such as alcohols and acids is that candidates link the **-**OH group to the carbon via the hydrogen instead of via the oxygen.

Correct Linkage



$-\overset{|}{\underset{|}{C}}-\ OH$

Incorrect Linkage

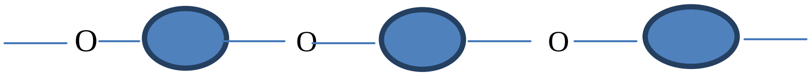


$-\overset{|}{\underset{|}{C}}-HO$

The correct products for Part (c) (ii) were *ethanoic acid and ethanol*.

For Part (d), a fair number of candidates were able to draw the structure of the polymer. However, the problems traditionally identified with polymer chemistry over the years continued to be evident in candidates' responses this year. These include the incorrect link between the monomers and failure to draw the ends of the polymer to correctly represent continuity. Several candidates were unable to give a suitable test to differentiate the monomer from the polymer.

The polymer required was starch and the structure is given below.



The expected observations for mixing the monomer and polymer with water is that the monomer will dissolve to give a colourless solution while the polymer is insoluble, forming a white suspension.

Candidates performed poorly on Part (e) as they *gave examples* of the polymer instead of *stating the type* of the polymer. The most common incorrect response was 'protein'. The correct response was *polyamide.* Polypeptide was also accepted. Most candidates were able to give a correct use of the polymer.

Question 4

Syllabus References: A: 2.8, 6.2, 6.3, 6.4, 6.15, 6.16; B2: 7.2

Candidates were tested on their knowledge of the periodic table and properties of elements from Groups 1, 2 and 7.

Performance on this question was also poor with a significant number of candidates scoring less than 5 of the 15 marks. This poor performance was primarily due to candidates' inability to write ionic and molecular equations and their seeming unfamiliarity with the reactions of the elements in Groups 1, 2 and 7.

The writing of the electron configuration in Part (a) was very well done by most candidates. However, some of the reasons for placing sodium in Period 3 were vague, for example, "It is placed in Period 3 because of the number of shells'. A better response would be *It is placed in Period 3 because there are three shells.*

The reaction of sodium with water was fairly well known. Most candidates knew that hydrogen gas was a product of the reaction but the majority of them could not write the equation. A few candidates identified the gas as oxygen instead of hydrogen. Generally, those candidates who identified the gas as hydrogen were able to correctly test for the gas. The most common error with this test was the use of a 'glowing splint' instead of a *lighted splint*.

Generally, the reactivity of elements down the group was well known. Most candidates correctly predicted that the reactivity of Element X would be greater than that of potassium and sodium.

Part (a) (iii) was misunderstood or ignored by a number of candidates. The question tested knowledge on the chemical properties of the oxides of metals and non-metals. Specifically, it required a simple laboratory test to differentiate a solution of the oxide of Element Y (a metal) from that of a solution of the oxide of sulphur. It was expected that the difference in pH would be used to make this distinction. Only the more able candidates got this correct. The solution of the metal oxide is basic while that formed when the oxide of sulphur is dissolved in water is acidic. A wide range of incorrect responses were submitted.

Part (b) (i) tested candidates' knowledge of the reactions of chlorine as an oxidizing agent. An ionic reaction was required for its reaction with aqueous iron(II) ions.

Perhaps because the previous part of the question tested group trends of metals, some candidates explained the reaction of chlorine and iron(II) sulphate in terms of chlorine's relative reactivity with respect to iron and overlooked the fact that chlorine was reacting in its capacity as an oxidizing agent. Candidates were confused about some concepts and this was evident in their failure to select the relevant concepts to answer questions.

Several candidates knew that iron(II) ions were oxidized while chlorine gas was reduced. However, many of them still confused oxidation and reduction. Some candidates were able to write the molecular equation but the majority of candidates was unable to write the ionic equations. Many of them seemed not to understand what were the species taking part in the reaction. The distinction between chlorine gas, chlorine atoms and chloride ions is still not clear and so various forms of chlorine were indiscriminately used in writing the equation. The balancing of charges was not well done even when the atoms were balanced. Candidates need help in understanding how to deduce state symbols for reactions, even in cases where reactions are unfamiliar.

The correct ionic equation for the reaction was

$$2Fe^{2+}(aq) + Cl_2(g) \longrightarrow 2Cl^{-}(aq) + 2Fe^{3+}(aq)$$

Part (b) (ii) tested candidates' knowledge of the group trends with respect to the relative oxidizing power of iodine and chlorine. Most candidates clearly knew that the reactivity of the halogens decrease down the group. However, here again, there was evidence that candidates were not discriminating between the reactivity of the elements in Group 7 and the reactivity of metals in the activity series. Hence, many candidates explained the difference in reactivity with iron(II) ions as "chlorine being higher that iron in the activity series and so it was able to displace iron". In doing so, they totally missed the point that chlorine and iodine are not metals. This speaks to a tendency to apply the principle of more active metals being able to displace less active metals from solution to the reactions of the halogens. While it is true that chlorine will displace iodine from a solution of the iodide, this is because chlorine is a stronger oxidizing agent and not because it is a more active metal. The relative oxidizing powers of iodine and chlorine were rarely considered in the responses to this question.

The expected response for this question was:

> *As the group is ascended, the oxidizing power of the halogens increases. Iodine is not a strong enough oxidizing agent to oxidize iron(II) ions.*

Question 5

Syllabus objectives: B2: 1.1, 1.2, 2.1, 2.2, 4.2

Part (a) tested candidates’ knowledge of the extraction of iron from its ore, using the blast furnace. Part (b) tested their knowledge of the activity series of metals and the reaction of heat on the hydroxides and nitrates of metals high up in the series. Candidates performed poorly on this question. A significant number of them did not attempt this question or did not earn any marks.

Most candidates who attempted Part (a) managed to get a mark for stating the three substances put into the blast furnace − the *ore*, *coke* and *limestone*. However, many candidates who attempted to write the formula for the iron ore did so incorrectly.

Surprisingly, many candidates failed to recall the reactions taking place in the blast furnace that lead to the production of iron. Generally, candidates were able to explain that the coke was first converted to carbon monoxide and were able to write this equation. However, they could not explain why carbon monoxide was used as the reducing agent instead of coke. The most common error was the use of carbon dioxide to reduce the iron instead of carbon monoxide.

In Part (b), the equation for the action of heat on the hydroxide of M was better known than that for the action of heat on its nitrate. The most common errors were to give M a valency of 1 rather than 2 so that the formulae of the hydroxide and nitrates were given as MOH and MNO_3 respectively, to produce hydrogen when the hydroxide was heated and to produce nitrogen dioxide when the nitrate was heated.

In Part (b) (ii), most candidates recognized that metal M could be extracted by electrolysis of the molten ore. Candidates were not complete in their explanations for why this was so and gave vague responses such as “metal is very reactive”. The required answer was:

> *M is more reactive than aluminium, since it can displace it from its aqueous solution and therefore it forms stable ores that require a strong method of reduction.*

In Part (c), many candidates gave physical rather than chemical properties of M. Most often quoted were the high melting point of M and its ability to conduct electricity.

Question 6

Syllabus Objectives: C1 1.2, 1.3, 1.4

Parts (a) and (b) tested candidates’ knowledge of the role of water, leavening agent and heat in making dough and required knowledge of equations for the actions of baking powder and yeast in making dough raie.

While many candidates seemed to have a general knowledge of the process of bread making, they incorporated limited reference of chemical concepts in their responses.

Most candidates described the role of water as ‘making it sticky or soft’. Only a few candidates used the terms *elasticity* or *viscosity.* With respect to the role of the leavening agent, candidates failed to mention aeration and generally, the responses did not relate the raising of the dough to the movement of the carbon dioxide. Candidates lost marks for not differentiating between the two processes for producing carbon dioxide from yeast and baking powder.

The majority of candidates mentioned the role that heat plays in cooking the dough and giving it the brown colour. However, hardly anyone associated the heat with the conversion of water to water vapour or to the expansion of carbon dioxide.

The ability to represent the various steps associated with making dough using chemical equations posed significant challenges for candidates. These equations were generally unknown. In most cases, chemical formulae were incorrectly written.

A good response for Part (a) should have addressed the following:

Role of Water

- Hydration of the protein to form a gluten – a viscoelastic complex
- Provision of moisture necessary for the fermentation of yeast
- Aeration of the dough during baking

Role of Leavening Agents

- The CO_2 produced on fermentation of the yeast aerates the dough causing it to rise.
- The CO_2 produced from the reaction between $NaHCO_3$ and an acid aerates the dough causing it to rise.

Role of Heat (any two of the following points)

- Heat fixes the colour, taste and shape of the dough.
- Heat causes expansion of the CO_2 during baking which causes the dough to rise.
- Heat serves to destroy the yeast and prevents further fermentation.
- Heat serves to convert the water to water vapour which expands on heating due to its gaseous state. This further increases the volume of the dough.

For Part (b), any two of equations (i)–(iii) and equation (iv) were required.

$$\text{(i)}\quad C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{enzyme in yeast}]{\text{maltase}} 2C_6H_{12}O_6$$

$$\text{(ii)}\quad C_6H_{12}O_6(aq) \xrightarrow[\text{enzyme in yeast}]{\text{zymase}} 2C_2H_5OH(aq) + 2CO_2(g)$$

$$\text{(iii)}\quad 2C_6H_{10}O_5(aq) + H_2O(l) \xrightarrow[\text{enzyme in flour}]{\text{amylase}} C_{12}H_{22}OH(aq)$$

$$\text{(iv)}\quad HX(aq) + NaHCO_3(aq) \rightarrow NaX(aq) + H_2O(l) + CO_2(g)\ \text{acid in baking powder}$$

Part (c), tested candidates’ knowledge of the hydrolysis of starch and the effect of iodine on the products of hydrolysis.

Many candidates recognized that the lack of the blue-black colour with iodine was due to the absence of starch but most of them failed to provide a suitable explanation for what might have happened to the starch. Only a few candidates mentioned the possibility that starch may have been hydrolyzed and deduced that the end product would be glucose. Some candidates mentioned that sucrose and other substances may be present. Some of them reported that starch was broken down to sucrose instead of glucose.

The expected response was that *moisture from the air would hydrolyse the starch at high temperatures to produce glucose. Hence, the resultant products would have a negative test with iodine.*

Paper 03/2 – Alternative to SBA

Question 1

Syllabus References: A: 3.3, 3.4, 3.6, 3.7, 6.12, 6.25

This question tested candidates' knowledge of standard solutions, volumetric analysis and electroplating. The maximum mark available was 26. Most candidates were able to score at least 8 out of 26.

Part (a) required candidates to

- (i) describe the preparation of a standard solution of aqueous sodium hydroxide containing X grams in 250 cm^3
- (ii) read the volume of acid used from the burettes, complete the table of results and determine the average volume of acid used for the titration
- (iii) identify a suitable indicator for the titration of NaOH and H_2SO_4 and explain how the endpoint can be determined
- (iv) write a balanced equation for the reaction between NaOH and H_2SO_4
- (v) calculate the mass of NaOH that was used to make 250 cm^3 of the standard solution.

It appeared as if many candidates had never prepared or were never exposed to a standard solution. In most cases candidates described a titration. Three simple steps were required to prepare a standard solution of aqueous NaOH containing X grams in a 250 cm^3 solution:

- Weigh out the X g of the NaOH pellets.
- Transfer all to a clean 250 cm^3 volumetric flask.
- Make the solution up to the mark.

Although most candidates were able to read the burettes accurately, a few read it backwards. In addition, the majority of candidates was able to correctly identify and utilize the best two readings to calculate the average volume of H_2SO_4 used. They were also able to identify suitable indicators but were vague about the colour change that would occur. It was expected that candidates would have stated the initial and final colours but most of them identified the final colour. Writing the balanced chemical equation for the reaction of the NaOH with the H_2SO_4 presented a challenge for a few candidates; the most common mistake was writing the formula for sodium sulphate as $NaSO_4$ instead of Na_2SO_4. For the most part, the calculations were well done, with the majority of candidates able to calculate the relative formula mass of the NaOH.

Part (b) focused on the concept of copper plating and required candidates to

(i) identify suitable materials needed for the electrodes as well as the electrolyte
(ii) draw a diagram to show the arrangement of the apparatus needed
(iii) state the type of reaction which occurs at the anode
(iv) write balanced equations for the reactions at the electrodes.

For the most part, candidates seemed familiar with copper plating. Some of them, however, did not know what the anode should be; the most common *incorrect* answer was graphite. In addition, those who gave the incorrect electrode thought it was H_2SO_4. Although most candidates recognized that oxidation occurs at the anode, a few of them misinterpreted the question and stated that electrolysis occurs at the anode. It was expected that the equation at the anode and cathode would have been written as
$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^{-}$ and $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$ respectively
but most candidates neglected to include the state symbols.

<u>Question 2</u>

Syllabus References: B2: 7.1, 7.2, 7.3

This was a qualitative analysis question in which candidates were required to deduce the observations that would be made when various tests were performed on an unknown solution Z. A maximum of 10 marks were awarded for this question and it was fairly well done. It should be noted however, that candidates should be aware of when there is a need to test any possible gases evolved as well as when it is more appropriate to state *no precipitate formed* rather than simply stating ‘no changes’ or ‘no reaction’. Also, most candidates were not aware that when copper turnings, followed by concentrated H_2SO_4, is added to a solution with nitrate ions that, in addition to the brown gas evolved which turns blue litmus red, the resulting solution will be blue in colour.

<u>Question 3</u>

Syllabus References: A: 6.10, 6.8

For this question, candidates were required to plan and design an experiment to make lead chloride crystals from samples of lead nitrate and sodium chloride crystals. This question was poorly done. It was expected that candidates would recognize that the following steps were required for the procedure:

- Make separate solutions of both lead nitrate and sodium chloride.
- Mix both solutions together.
- Filter the resulting solution.
- Wash residue with cold water.

Instead, many candidates mixed both salts then tried to dissolve the mixture in water or dissolved one salt then tried to add the other one to it. Some candidates even thought that after mixing the crystals, they could heat the mixture until it melts forming lead chloride on cooling. Other common mistakes were neglecting to wash the residue and evaporating the solution rather than filtering it.

However, many candidates were able to gain marks for listing the pieces of apparatus necessary. This was due mainly to the fact that the apparatus was only dependent on the procedure the candidate proposed.

In Part (c), candidates were required to state one safety precaution and one experimental precaution that should be taken into consideration. The safety precaution proved much less challenging than the experimental precaution. Expected responses were as follows:

- Safety – wearing gloves etc.
- Experimental – excess sodium chloride could be used or ensure that the crystals are washed.

Part (d) required candidates to discuss two possible reasons why the yield is unlikely to be 100 per cent in preparing a sample of lead chloride. This part of the question was most challenging for candidates. The main points raised by candidates were the possibility of contamination of the lead chloride, difficulty in drying the sample, hence having a yield of more than 100 per cent and difficulty in transferring all the solid material. The point that there was a possibility of the filter paper tearing was also mentioned but it was not awarded any marks as this was considered to be due to poor experimental procedure.