CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THECARIBBEAN SECONDARY EDUCATION CERTIFICATE

JANUARY 2010

CHEMISTRY
GENERAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

This year, the number of candidates registering for the examination in January increased by 45 per cent when compared to January of 2009. However, the number who actually wrote all the required papers increased by 33 per cent (from 425 to 565).

A slight improvement was noted on the candidates' performance at this sitting of the examination compared with 2009. On Paper 2, candidates did fairly well on Questions 1, 2 and 4 but performed unsatisfactorily on the other questions. Several issues highlighted in previous reports continue to cause concern as the weaknesses identified still persist. One example is the performance on the questions that test organic chemistry. For Paper 2, a significant percentage of the candidates did not attempt Question 3 and those who attempted it did poorly.

A number of candidates seemed not to have been adequately prepared for Section C of the syllabus. The few students who wrote Question 6 which tested knowledge of clay and cement performed unsatisfactorily. Several responses to questions were vague, missing reference to key concepts for definitions and lacking depth where explanation was required. In many instances, the responses were superficial which may have been due to the fact that enough care was not given to differentiating and clarifying concepts as candidates prepared for these examinations.

Candidates wrote the Alternative Paper to the School Based Assessment (SBA) for the first time. The performance on the data analysis question was commendable but improvement is needed in the areas of qualitative analysis, and planning and designing.

DETAILED COMMENTS

<u>Question 1</u>

Syllabus References: A: 5.4, 3.3, 3.4, 6.10; B2: 7.1, 7.2

Part (a)

In this section, candidates were required to:

(i) explain how a salt is formed

(ii) distinguish between anhydrous and hydrated salts

(iii) write a balanced equation for the reaction of dilute sulphuric acid and copper(II) oxide

(iv) calculate the mass of anhydrous copper(II) sulphate that would be formed from a given mass of copper(II) oxide when reacted with a given volume of dilute sulphuric acid of known concentration

(v) plot a graph of mass of anhydrous salt produced against mass of copper(II) oxide used

(vi) use the graph to determine the mass of copper(II) sulphate that would be produced from a given mass of copper(II) oxide, and (vii) explain why there is no change in the mass of salt produced for two experiments (where the former was the limiting amount).

Candidates' Performance

The average mark for this question was 8.5 out of 25 or 34 per cent. The majority of candidates earned marks for explaining how a salt is formed, but many candidates did not mention 'water of crystallization' in their responses in explaining the difference between a hydrated salt and an anhydrous salt. Many candidates earned the 2 marks for the equation for the reaction between sulphuric acid and copper(II) oxide. Many candidates were able to correctly calculate the mass of anhydrous copper(II) sulphate from the given mass of copper(II) oxide, calculating the correct number of moles of copper(II) oxide, stating the correct mole ratio and relating it to the mass of product. The majority of candidates obtained the maximum 3 marks for the graph, and were able to correctly read off (interpolate) the mass of anhydrous copper sulphate produced from a given mass of copper(II) oxide. Though the responses were somewhat varied in explaining why the mass of copper sulphate had reached a maximum after a while, many candidates realized that sulphuric acid was the limiting reagent and that addition of more copper(II) oxide would cause no further reaction.

Common Incorrect Responses

- 1(a)(ii) Hydrated salts have water and anhydrous salts do not.
- 1(a)(vii) No more copper(II) oxide will dissolve.

Expected Responses

- Hydrated salts contain water of crystallization and anhydrous salts do not.

Part (b)

Part (b) tested candidates' knowledge of the identification of cations using qualitative analysis. An aqueous solution of Substance X (containing iron(II) and ammonium ions) was reacted with aqueous sodium hydroxide, dropwise and then in excess. Either the observation or the inference was given for each test, and the candidates were required to fill in the corresponding inference (with supporting equation(s)) or observations, respectively.

Candidates' Performance

The majority of the candidates correctly indicated that red litmus changed to blue in the presence of an alkaline gas. Very few earned the 2 marks for the equation showing the reaction of ammonia and hydrogen chloride gases to form ammonium chloride.

Part (c)

In Part (c), candidates were required to describe an appropriate method that could be used to produce a pure solid sample of silver chloride starting with a solution of silver nitrate. The hint was given that all silver salts are decomposed by light.

Candidates' Performance

Some candidates failed to give the name of a soluble source of chloride ions, but a large number gave hydrochloric acid, which is a very good choice. Even though the hint was given that silver salts are decomposed by light, the majority of candidates did not state that light was to be excluded from the product, or that diminished light was to be used.

Common Incorrect Responses

- The salt should be placed in light to decompose.

Expected Responses

Candidates should indicate a soluble source of chloride, filtering the insoluble silver salt, washing impurities from the product and doing the preparation in reduced light, or in the absence of light.

<u>Question 2</u>

Syllabus References: A: 4.1, 4.2, 4.3, 4.5, 4.6, 4.7, 4.8

This structured question addressed the topic of structure and bonding. In Part (a), candidates were expected to complete a table by identifying the structure of one form of carbon, labelled V, based on the given appearance, melting point and electrical conductivity as well as to identify the electrical conductivity of another form of carbon, labelled Q, based on the appearance, melting point and structure given. Candidates were also expected to state the term used to describe different forms of an element.

In Part (b) (i), candidates were required to identify the forms of carbon from the information given in Part (a). In Part (b) (ii), candidates were given a partially drawn structure of Q and asked to complete the diagram showing the bonding within and between the layers. In Part (b) (iii), they were expected to state the use and the associated property of the two forms of carbon and in Part (b) (iv), they were required to explain why an ionic solid conducts electricity when molten but not when solid.

Candidates' Performance

This question was relatively well done; almost half of the candidates scored 8 or more out of the 15 available marks.

Expected/Common Incorrect Responses

In Part (a), most candidates were able to identify correctly the structure of V as giant covalent and that Q was an electrical conductor. However, it is clear that many candidates were confused by the terms 'allotrope' and 'isotope'.

Part (b) (ii) and (iv) seemed to be more challenging to candidates. Many could not complete the partial structure of graphite and those that were able to did not differentiate the covalent bonds from the intermolecular forces. When asked to explain why an ionic solid conducts electricity when molten but not when solid, many candidates incorrectly responded in terms of mobile electrons rather than mobile ions.

Part (c) was generally well done although some candidates seemed not to realize that both Cl and I have 7 electrons in their valence shell.

<u>Question 3</u>

Syllabus References: B1: 4.1, 4.2, 4.3, 4.4, 2.8, 3.8

Candidates were required to define polymerization, identify the type of polymerization reaction from given equations, name polymers from given structures and give one use of each. Candidates were also required to write the equation for the reaction of magnesium with ethanoic acid and state whether the reaction would go at room temperature.

Part (a)

In this part, candidates were required to define the term 'polymer'.

Candidates' Performance

The majority of candidates were able to give a definition which included 'monomer' and also indicated that a polymer is a long chain molecule.

Common Incorrect Responses

The following response is **not accurate** enough, that is, it should reflect that a polymer is a long chained molecule:

- A polymer is made from the joining of more than one monomer.

Expected Response

A polymer is made from the joining of large number of (many) monomers to form a long chain.

Part (b)

Two polymerization equations were given depicting the addition polymerization of ethene and the condensation polymerization of a di-acid and a di-alcohol. Candidates were required to identify the equation which depicted 'addition polymerization', name the polymers in the two equations and give one use of each of the polymers in these equations.

Candidates' Performance

Most candidates were able to identify correctly equation (1) as the addition polymerization reaction but had difficulty naming the polymers (polyethene and polyester) in Equations 1 and 2, respectively. The majority of candidates was able to give one use of the two polymers - polyethene used in making plastics was a common response, as well as polyester used in making clothing/fabric.

Part (c)

Candidates were required to write a balanced chemical equation for the reaction between ethanoic acid and magnesium metal, and to indicate whether the reaction would proceed at room temperature.

Candidates' Performance

Most candidates gave an equation showing the production of a salt and hydrogen gas but some candidates had magnesium as a univalent metal ion. Many gave unbalanced equations. Many correctly indicated that the reaction would proceed at room temperature.

Common Incorrect Responses

- $Mg + CH_3COOH \rightarrow CH_3COOMg + H_2$

Expected Responses

The correct name of the polymer in Equation 1 is polyethene, but polythene and polyethylene are also acceptable. The polymer in Equation 2 is a polyester. The uses for polythene include: plastic bags, containers for cleaning agents, mixing bowls. The uses for polyesters include: clothing, ropes, car bodies, and roofing sheets when polyesters are reinforced.

The correct equation is: $Mg(s) + 2\ CH_3COOH(aq) \rightarrow Mg(CH_3COO)_2 + H_2O(l)$

Part (d)

Candidates were required to (i) circle the peptide bond (link) on a figure showing the partial structure of a protein molecule containing three amino acid units, (ii) draw the fully displayed structure of one of the amino acid molecules that would be produced upon hydrolysis, and (iii) state two conditions under which proteins can be hydrolysed.

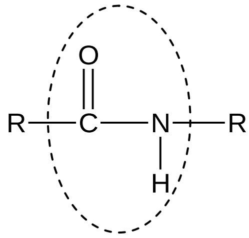
Candidates' Performance

A number of candidates had difficulty in correctly identifying the peptide (amide) link, arbitrarily encircling different segments of the structure.

Common Incorrect Responses

- A number of candidates incorrectly chose the C-N single bond, for example, between the amino acid and the carboxyl group as the peptide linkage.

Expected Responses

The amide link is encircled in the structure: 

Question 4

Syllabus References: A: 6.17, 6.18, 6.19, 6.20, 6.21, 6.23; B1: 1.1, 1.2, 1.4, 1.5, 1.6

This question was mixed with parts coming from the sub-topics of conduction of electricity by electrolytes, and isomerism in alkanes and alkenes. Some candidates wrote their responses in the body of the question although the instructions clearly indicated that they should use the blank pages reserved for Question 4. (Candidates should be reminded at the examination centres to refrain from writing in the body of the question.)

Part (a)

In this part of the question, candidates were asked to indicate whether a bulb would glow when a switch is closed to complete a circuit after a substance was placed in contact with two electrodes. The investigation was carried out on two pairs of substances.

Part (a) (i)

Candidates were asked to state whether the bulb would glow for **solid lead bromide** and **molten lead bromide**.

Candidates' Performance

Generally, candidates performed below the required standard with 28 per cent of candidates scoring 8 or more of the possible 15 marks for the question.

Common Incorrect Responses

- Some candidates correctly stated that molten lead bromide would cause the bulb to glow, but incorrectly gave the reason as the presence of mobile electrons.

Expected Responses

The cations and anions are mobile in the molten lead bromide and are therefore able to carry the electric charge.

Part (a) (ii)

Candidates were asked to state whether the bulb would glow brighter for solutions of **1 mol dm^{-3} hydrochloric acid** or **1 mol dm^{-3} ethanoic acid**.

Candidates' Performance

Many candidates gained the mark for correctly stating that hydrochloric acid would cause the bulb to glow brighter while some had difficulty giving an explanation. Many stated that HCl is completely ionized in dilute solution. The weaker candidates mixed up Pair 1 and Pair 2.

Common Incorrect Responses

- Ethanoic acid would cause the bulb to glow brighter.

Expected Responses

Hydrochloric acid is the stronger electrolyte and is completely ionized; therefore, more ions are available in solution to carry the electric charge.

Part (a) (iii)

Candidates were asked to write a balanced equation for the reaction occurring at the cathode for either of the solutions, **1 mol dm^{-3} hydrochloric acid** or **1 mol dm^{-3} ethanoic acid**.

Candidates' Performance

Performance on this section was generally weak, and candidates had great difficulty in writing the correct ionic (cathodic) equation.

Common Incorrect Response

A number of candidates incorrectly wrote the equation as: $H^+ + e^- \rightarrow H$

Expected Response

- $2\,H^+(aq) + 2\,e^- \rightarrow H_2(g)$

Part (b)

Four fully displayed structures of hydrocarbons with four carbon atoms were given, and candidates were required to (i) write the name for one structure (2-methyl propene), (ii) state which of the structures are isomers, (iii) state, with reason, which two hydrocarbons belong to the same homologous series, and (iv) write the name of the homologous series.

Candidates' Performance

Generally, candidates performed well on this part of the question which was very encouraging, bearing in mind that the performance in organic chemistry is usually weak. Overall, candidates did not give three isomers, **a**, **b** and **c** but gave only two. They recognized that **a** and **b** belonged to the same homologous series because of the presence of a C=C double bond. Some stated that **a** and **b** belonged to the alkene group and have the same general formula.

Common Incorrect Responses

- butene, but-2-ene, methyl prop-2-ene
- alkene general formula - C_4H_8

Expected Responses

(i) 2-methyl propene, methyl propene

(ii) **a**: 2-methyl propene, **b**: but-2-ene and **c**: cyclobutane are all isomers of C_4H_8.

(iii) **a**: 2-methyl propene and **b**: but-2-ene belong to the **alkene** homologous series, both having a carbon-carbon double bond (C=C).

(iv) the general formula for the alkene homologous series is $\mathbf{C_nH_{2n}}$.

Question 5

Syllabus References: B2: 1.3, 3.1, 7.2

This compulsory question was an extended response based on the inorganic section of the syllabus.

In Part (a) of this question, candidates were asked to suggest how they could use a lighted splint and a piece of moist litmus to distinguish among three gases, Cl_2, H_2 and N_2.

In Part (b), candidates were asked to explain what occurs at the anode and cathode in the electrolysis of brine and to write an ionic equation for the reaction at the anode. They were also required to suggest why brine was used instead of dilute sodium chloride for the industrial preparation of Cl_2 and write an ionic equation that will justify their suggestion.

Candidates' Performance

This question was very poorly done. Candidates seem to need adequate exposure to test gases in the laboratory. Less than 15 per cent of the candidates scored more than 8 out of 15.

Expected/Common Incorrect Responses

Part (a)

Candidates were expected to recognize that H_2 will react with the lighted splint giving a 'pop' whereas, Cl_2 will bleach the litmus paper but N_2 will not react with any of the two. Most candidates knew that H_2 would react with the splint and that Cl_2 will react with litmus but not many indicated that H_2 will give a pop or that the paper would be bleached by the Cl_2. Very few candidates knew that N_2 would not react with the splint or the litmus.

Part (b)

Many candidates appeared unfamiliar with the industrial preparation of Cl_2. While some candidates recognized that Cl^- ions would migrate to the anode, many referred to them as chlorine ions rather than chloride ions. Some candidates confused the reactions occurring at the anode and cathode. Some even wrote that the chemical symbol for brine was Br.

The equation proved difficult for most. One common error was the placement of the electrons in the equations, for example $2Cl^- + 2e^- \rightarrow Cl_2(g)$ was written instead of $2Cl^- - 2e^- \rightarrow Cl_2(g)$.

In Part (iii), candidates were expected to recognize that with dilute NaCl the OH^- ions would be discharged in preference producing O_2 at the anode instead of Cl_2. Very few candidates made this assertion. In response to the question why brine is used instead of NaCl, the following common misconceptions arose:

- With brine the reaction will go faster.
- Brine is a stronger/better/purer electrolyte.
- Since brine is more concentrated, more Cl_2 will be produced than with dilute NaCl.

Question 6

Syllabus References: C2: 5.3, 5.4, 5.6, 5.7, 5.8

This question was an optional question which related to Section C2 of the syllabus: The Chemistry of Some Materials Found in and Around the Home.

In Part (a), candidates were required to identify the chemical components of clay, suggest a possible source of 'glass' in fired clay and relate the use of clay in pottery for making items of different shapes to one of its properties.

In Part (b), candidates were asked to give an explanation for a mason advising his client to keep a freshly completed concrete floor moist.

In Part (c), candidates were asked to identify one example each of a plant and animal fibre that could be used to make fabric, state the chemical composition of plant and animal fibres and to suggest two chemical tests to distinguish between them.

Candidates' Performance

Less than 15 per cent of the candidates attempted this option. The entire question was poorly done indicating a lack of preparedness for this topic. The majority of the candidates who attempted it scored less than 2 out of 15; no one scored more than 8 out of 15.

Expected/Common Incorrect Responses

In Part (a), candidates were expected to know that the components of clay were silica and metal silicates. However, most confused chemical composition with the physical attributes such as particle size and water retention. Very few candidates were able to link the glassy look of clay to the melting of the sand or silica. Many of those who attempted this question referred to the practice of adding a chemical glaze. When asked to relate the use of clay in pottery for making items of different shapes to one of its properties, instead of using the term plasticity - its ability to be moulded - some candidates used terms such as flexibility or malleability. The majority seemed to confuse properties with uses and gave responses such as flower pots.

Candidates were not successful at earning marks in Part (b) of the question. It was expected that candidates would have mentioned that cement can harden in both water and air and that water is needed for crystal formation which continues long after the initial setting. Candidates however, concentrated on the process without using the composition of cement in these explanations. For example, one common **incorrect** answer was that the water filled the air spaces which, if left, would cause the cement to crack.

In Part (c), most candidates were able to give correctly an example of an animal fibre and a plant fibre. However, many did not know that the chemical composition of animal fibres was protein and plant fibre was cellulose. Candidates also did not demonstrate ample knowledge of chemical tests that could be used to distinguish between an animal fibre and a plant fibre. Some common **incorrect** and vague answers were:

- Iodine test for starch
- Use different chemicals on the fibres
- Heat or burn them
- Use DNA testing

<u>Question 7</u>

Syllabus References: C 6.1, 6.3, 6.4, 6.7, 6.10; B2: 6.2

This question was also an optional question and related to Section C2 of the syllabus: The Chemistry of Some Materials Found in and Around the Home.

In Part (a), candidates were asked to name two elements essential for plant growth as well as to identify the deficiencies associated with the named elements.

In Part (b), candidates were presented with a diagram of an incomplete nitrogen cycle which they were asked to complete.

In Part (c), candidates were asked to suggest one way in which lime can cause nitrogen to be lost from the soil and to write a representative ionic equation.

In Part (d), candidates were asked to identify two advantages and a possible limitation of using hydroponics as an alternative method of growing crops.

Candidates' Performance

This question was poorly done by the candidates who attempted it. More than 85 per cent of the candidates scored less than 7 out of 15 indicating a lack of preparedness for this option as well.

Expected/Common Incorrect Responses

Part (a)

Most students were able to identify at least two elements that were essential for plant growth. However, they were a few candidates who incorrectly listed sunlight, carbon disoxide and water as elements. Identifying specific deficiencies presented the greatest challenges in this section; for the most part, candidates just noted poor plant growth.

Part (b)

It appeared as if many candidates were not familiar with the terms associated with the nitrogen cycle, for instance, in many cases instead of writing nitrogen fixation some wrote 'nitrifying' or 'nitronifying'. However, most candidates were able to identify correctly that nitric acid is converted into nitrates.

Part (c)

Some candidates believed that 'lime' referred to the citrus fruit containing ascorbic acid hence being acidic in nature rather than alkaline. Some candidates listed the effect that lime would change the overall pH of the soil and noted that it will kill the nitrogen-fixing bacteria in the soil.

Not many candidates identified that nitrogen is removed from soil in the form of ammonia as a result of the lime reacting with the ammonium ions in the soil. As a result, they were unable to write the associated ionic equation ($OH^- + NH_4^+ \rightarrow NH_3 + H_2O$).

Part (d)

Most candidates were able to identify the advantages and at least one limitation associated with the use of hydroponics, although some thought that too much water would damage the plants. Some correct responses for the limitations are:

- It is expensive.
- There is a need for highly skilled employees.
- Precise measurements are needed for chemicals etc.

Paper 03/2 – Alternative to SBA

Syllabus References: A 3.3, 3.4, 3.7 and B2: 7.1, 7.3

Question 1

In this question, candidates were required to determine the optimum mole ratio in which the hypochlorite ions react with thiosulphate ions in the presence of a base when the temperature produced from reacting different volumes of hypochlorite ions with thiosulphate ions was measured. The question carried 26 marks and the majority of the candidates scored more than 16 marks.

Part (a)

Candidates were required to:

(i) complete a data table based on three sets of thermometer readings

(ii) plot a graph of change in temperature against experiment number and determine the maximum change in temperature (ΔT)

(iii) calculate the number of moles of hypochlorite and thiosulphate ions when ΔT is at its maximum and hence use the mole ratio to balance the equation for the reaction.

Candidates' Performance

Candidates did very well on completing the data table, plotting the graph, deducing the maximum change in temperature from the graph and determining the volume ratio of Solution 1: Solution 2 when ΔT was at its maximum. However, a large number of candidates were unable to calculate the number of moles of ClO^- in Solution 1 and $S_2O_3{}^{2-}$ in Solution 2. Many candidates used the total volume of solution provided instead of the volume ratio at the maximum temperature change to calculate the number of moles.

Expected Response

Candidates were expected to use 4:1 for the ratio of ClO^- in Solution 1: $S_2O_3{}^{2-}$ in Solution 2. The correct balanced equation was

$$4ClO^-(aq) + S_2O_3^{2-}(aq) + OH^-(aq) \longrightarrow 2SO_4^{2-}(aq) + 4Cl^-(aq) + H_2O(l)$$

Parts (b) and (c)

Candidates were required to state two precautions to be taken during the reaction between hypochlorite ions and thiosulphate ions and one possible source of error.

Candidates' Performance

A number of students were unable to identify two precautions. Many used incorrect experimental procedures as precautions. Likewise, they were unable to state sources of error.

Expected Response

Experimental precautions should include any action that could cause danger or affect the quality of the data collected. Hence, possible precautions include avoiding contact between bleach and skin as bleach is corrosive and ensuring that the thermometer bulb is totally immersed in the solution when recording temperature.

Common Incorrect Response

Some common incorrect precautions included:

- Making sure that the measurements are correct.
- Not contaminating the solution.
- Always reading the burette below the meniscus.
- Working in an enclosed area.

Some common incorrect sources of error were:

- Taking the wrong measurement.
- Losing some of the liquid.

<u>Question 2</u>

General Comments

This was the qualitative analysis question and tested Syllabus Objectives B7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when an unknown solid Y was subjected to a series of tests.

Candidates' Performance

Overall, the question was not well done. The average score for this question was 22 per cent. Many candidates seemed to be unfamiliar with the reactions and were unable to deduce the observations that matched the inferences recorded. Many terms such as residue, precipitate, solution and filtrate were incorrectly used.

Expected Response

Candidates were expected to record the presence of a white precipitate, soluble in excess sodium and ammonium hydroxide for Tests (a) (i) and (iii) respectively, while there should be no visible change for Test (a) (ii). Test (b) which confirmed the presence of chloride ions should first yield a colourless filtrate for Part (i) and a white precipitate soluble in aqueous ammonia for Part (ii).

Common Incorrect Response

Many candidates recorded coloured precipitates indicative of the presence of iron and copper ions.

<u>Question 3</u>

This question tested the planning and design skill. Candidates were required to plan and design an experiment to determine whether tap water could be made harder by adding various metal nitrates. Most of the candidates who attempted this question scored less than 5 marks. It appeared that candidates did not understand the concept 'hard water'. Many candidates tested the effect of the ions on water hardness by adding them all to the same volume of water instead of to separate quantities of water. Some also thought that it was the nitrate ion rather than the cations that made the water hard.

Candidates' Performance

Most candidates were able to obtain at least one mark for stating the apparatus needed which was dependent on the method that they selected. Candidates lost marks if they failed to include essential apparatus based on their method.

Many candidates did not include a control in their plan. This was important given the stated hypothesis. Candidates were able to gain marks for stating the variables to be controlled but most did not give the specific data to be collected to test the hypothesis.

In the discussion of the results, candidates lost marks for not discussing how the data to be collected would be used to evaluate the hypothesis.

Expected Response

A response for the method and the discussion of results which was awarded full marks is given here.

Procedure

- Fill each of six boiling tubes with 5 cm^3 of water.

- To one boiling tube, place a block of soap and shake for five seconds. Measure the height of the lather formed and record that value.

- To the other five boiling tubes, add one of the nitrates to each (in equal volumes) and a block of soap.

- Cover each one with a rubber bung, shake each for five seconds and record the height of the lather produced.

Variables to be Controlled

- The temperature (should remain at room temperature)
- The size of the block of soap
- The volume of water and nitrates used

Discussion of Results as they Relate to Hypothesis

When the heights of the lather in the boiling tubes with the nitrates are compared with that in plain water, if more lather is produced, the water got softer. If less lather is produced, the water gets harder. If the same amount of lather is produced, the water did not get harder or softer.