C A R I B B E A N E X A M I N A T I O N S C O U N C I L

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION

MAY/JUNE 2013

CHEMISTRY
GENERAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

The overall performance of the candidates on this sitting of the examination was not markedly different from previous sittings. The report on performance in the CSEC examination highlights the common areas which the candidates seem to find difficult as well as the nature of the errors that they make. It is hoped that students and teachers will use this information to conduct self-assessment, identify strengths and weaknesses and so better prepare for future examinations.

Most candidates demonstrated adequate knowledge of the important concepts in the following areas:

- Plotting graphs and reading values from graphs
- Factors that affect the rate of reactions
- Properties of alloys
- Factors affecting the discharge of ions at the electrodes
- Understanding of global warming

Some of the factors contributing to the unsatisfactory performance of candidates include:

- A tendency for responses to be superficial
  - Many candidates lost marks because they wrote in general or vague terms. Their language of chemistry is not very well developed. One consequence was the tendency to use related terms interchangeably although the terms have significant differences in meaning. For example, candidates often interchanged '*dilute*' and '*weak*' when referring to acids.
  - Too many candidates tended to pay little attention to correct explanations for known phenomena. For example, there is general knowledge that catalysts will increase the rate of a reaction but the reason for this is not fully appreciated. As a consequence, candidates did not discriminate well especially in the multiple-choice questions. In response to Question 5 on Paper 02, many candidates stated, generally, that the reason for the discharge of the hydrogen was "the position of the ions in the electrochemical series", but did not give the relative positions of the ions in the series.
  - Teachers are encouraged to insist on greater accuracy in students' oral and written responses.

- Limited understanding of concepts
  - Many candidates gave inadequate or inappropriate answers because they did not understand terms used in the questions or they used concepts loosely when writing their responses. Candidates showed limited understanding of terms such as *precipitate* (Question 1), *discharge* (Question 2), and *physical properties* (Question 5). *Reactivity series* was confused with *electrochemical series* and the terms *react*, *reactive* and *un-reactive* were often used without explanation of the nature of the reactions being described.
  - Several candidates had challenges with calculations of problems involving the mole where a stepwise approach to problem solving was not given in the question.
  - Candidates often used incorrect units and statements in calculations, thus demonstrating weak conceptual understanding.
  - Many candidates seemed not to understand the principles governing separation of mixtures.
  - Several candidates confused the element with its ion, for example, referring to the ion as Pb instead of Pb^{2+}

- Interpreting questions
  - It appeared that candidates were not sure what was required by instructions such as *compare* and *explain*.
  - Many candidates did not understand what types of reactions could readily be conducted in a laboratory.

- Writing and balancing equations and interpreting chemical reactions
  - Many candidates still struggled with writing ionic equations, mainly because they did not learn the valencies of common elements and radicals and so could not write the correct charges of the ions.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. The performance of this paper improved slightly compared with 2012. The mean score earned by candidates increased from 50 per cent to 55 per cent, with a standard deviation of 11.

Paper 02 – Structured and Extended Response Questions

<u>Question 1</u>

Syllabus References: A: 3.3, 3.4, 4.8, 5.4, 6.10, B2: 7.1, 7.2, 7.3

Part (a) (i) – (v) was based on an experiment to determine the effect of temperature on the solubility of potassium iodide. Candidates were required to calculate from the given data, the mass of potassium iodide (KI) that dissolved in 100 cm^3 of water at different temperatures, and plot the graph of mass of salt dissolved, against temperature. Using the graph, they were then required to determine the solubility of KI at various temperatures and calculate its concentration at 30 ^oC.

Most candidates were able to score the first 6 marks on the paper by correctly completing the table, plotting the points, drawing the best straight line to complete the graph and determining the solubility of the KI at 70 ^oC from the graph. Parts (iv) and (v) were more challenging as many candidates did not know how to determine the mass of solid that would be formed when the temperature was cooled from 70 ^oC to 30 ^oC. The better candidates scored full marks on these sections. For Part (v), candidates knew how to find the molar mass of KI and calculated the number of moles of KI produced at 30 ^oC. However, many did not know how to continue from there to calculate the molar concentration. Too many candidates used an incorrect reading from the graphs for the mass of salt at 30 °C and so lost marks.

The expected responses were:

(ii) The masses for the corresponding temperatures were:

20 ^oC	40 ^oC	60 ^oC	80 ^oC
162g	196 g	230 g	264 g

(iii) The solubility at 70 ^oC from the graph was 247 g/100 cm^3.

(iv) The mass of KI that would precipitate out when the solution was cooled from 70 ^oC to 30 ^oC was determined by subtracting the solubility at 30 ^oC from the solubility at 70 ^oC. These values were obtained from the graph.

Mass of salt precipitated = 247 − 180 = 67 g/cm^3.

(v) R.M.M. KI = 39 + 127 = 166
No. moles KI = 180 / 166 moles
At 30 °C, 100 cm^3 contains 180 / 166 moles
1000 cm^3 contains (180 / 166) × (1000 / 100) = 10.8 mol

Part (b) tested candidates' knowledge of why potassium iodide was very soluble in water but only sparingly soluble in ethanol.

Many candidates performed poorly on this question, as it appeared that they did not interpret the question correctly. They did not take into account that the question compared the solubility of KI in water and in ethanol. There was also evidence that some concepts were not clearly understood and there was a tendency to provide explanations at a superficial level; for example, there was widespread use of informal language and clichés such as *like dissolves like* and *water is a universal solvent*. The more common incorrect responses resulted from the following:

- Several candidates took the extreme positions that water was *polar* and ethanol was therefore *non-polar*. This statement is incorrect as ethanol is a polar solvent but not as polar as water.
- KI was described as *polar* instead of *ionic*.
- The difference was ascribed to differences in reactivity and ethanol was described as being *less reactive* than water.

Consequently, there were responses such as:

> *Water is a polar solvent. Ethanol is not polar so it does not fully dissociate the potassium iodide. It is not a good solvent.*
>
> *The statement is true because potassium iodide is an ionic compound and one property of ionic compounds is that it is soluble in water but insoluble in organic compounds such as ethanol.*

Both statements are only partially correct. The question required an explanation, which means that candidates were required to give reasons. These reasons should therefore indicate why ethanol, being polar, would not completely dissolve potassium iodide.

The expected response was

> *Potassium iodide is an ionic solid and dissolves in water, a polar solvent. It is only partially soluble in ethanol because although ethanol is polar, it is not as polar as water.*

Part (c) tested candidates' knowledge of how to separate two soluble salts, sodium sulfate and sodium chloride, in the solid state.

Candidates performed poorly due to careless reading of the question and limited knowledge regarding solubility of common salts. Responses also showed that candidates were familiar with techniques for separating mixtures but were not able to apply the principles to this unfamiliar context.

Common Incorrect Responses

It did not appear that the majority of the candidates considered that the two solids were ionic compounds that were both soluble when they attempted to answer this question. A wide range of suggestions was made for the separation. Some of the more common ones were fractional distillation and sublimation.

More than a third of the candidates assumed that sodium sulfate was insoluble and suggested *filtering the mixture after dissolving the sodium chloride in wate*r. Many overlooked that a mixture was given and treated the two solids as separate. Still others assumed that the mixture was a liquid although the question stated that the mixture was a solid. In responding to this section, many candidates used the term *precipitate* incorrectly. Assuming that the sodium sulfate was insoluble, they described the sodium sulfate as forming a *precipitate* and the sodium chloride as going into solution after water was added. This is an incorrect use of the term *precipitate* which refers to a solid coming out of solution. In this case, had the sodium sulfate really been an insoluble salt, that would not have been the case as it was a solid present from the start that did not dissolve on mixing with water.

Expected response

The easiest approach to separating the mixture would be to first make a solution by mixing with water as both solids were soluble and then precipitating out one of the salts leaving the other in solution. The new mixture could be filtered and filtrate crystallized to give the salt. Hence, barium nitrate could be added to remove the sulfate and leave sodium chloride in solution. Instead, silver nitrate could be added to remove the chloride. Following filtration, the filtrate could then be crystallized to obtain the solid.

Part (d) of the question tested knowledge of two common chemical tests on an unknown solid for which the observations were recorded.

This was also another task on which candidates performed unsatisfactorily. These common tests were clearly not familiar to a wide cross-section of candidates, indicating that limited practical work was done in this area.

Common Incorrect Responses

- The brown gas was described as *bromine* and *iron.*
- The equation of the formation of the yellow precipitate was given as $Pb^{2+} + I^{-} \rightarrow PbI_2$.
- No interpretation was given for the change on the blue litmus.
- Lead or Pb was present instead of Pb^{2+} or lead ions.

Expected response

Test (i) – Nitrogen dioxide produced or nitrate ion present; Acidic gas is present.
Test (ii) – Yellow precipitate is lead iodide or lead ions are present.

<u>Question 2</u>

Syllabus References: A: 4.1, 4.2, 4.3, 4.8, 6.1, 6.2, 6.4

This question tested candidates' knowledge of trends down Group 2 and Group 7, and across the period. The question also tested candidates' knowledge of bonding in and general properties of covalent compounds.

The following table was given:

Na	Mg		Al	Si	P	S	Cl	Ar
	X						Y	

Candidates were NOT required to identify X and Y.

In Part (a) (i), candidates were required to compare the ease of ionization of two elements, X and Mg, and to provide a suitable explanation for their answer.

The majority of candidates correctly stated that X is more easily ionized than Mg. However, many were unable to give the correct explanation, and only rephrased the answer to the previous part of the question, stating that as the group is descended the ionization energy decreases.

Common Incorrect Responses

Many candidates simply stated that ionization energy decreases down the group. This is an observed trend and NOT an explanation. Other incorrect responses included:

- X is lower down in the periodic table.
- X is lower in a group.
- Mg ionizes faster than X.

Expected Responses

The correct trend is that X is more easily ionized that Mg.

The explanation should focus on some factor that varies, and which leads to the decrease in ionization energy as the group is descended. As the group is descended, the number of shells increases and this causes an increase in the atomic radius. This increase in atomic radius means that the valence electrons are further from the nucleus and therefore are attracted less by it. The increase in the number of shells causes greater shielding of the valence electrons from the nucleus. Both of these factors result in a decrease in ionization energy down the group.

In Part (a) (ii), candidates were required to compare Cl and Y according to their oxidizing power, and to provide a suitable explanation for their answer.

Again, many candidates had the correct trend and correctly stated that Cl is a stronger oxidizing agent than Y, but were unable to provide correct explanation.

Common Incorrect Responses

- Oxidizing power increases down a group.
- Y is more reactive than Cl.
- Y is higher than Cl in the reactivity series.

Expected Responses

As Group 7 is ascended, electronegativity increases. That is, atoms higher up in the group accept electrons more readily from atoms of other elements. As the group is ascended, the number of shells decreases. This means that the outer shell is closer to the nucleus. As a result there is less shielding and so it is easier for electrons to be added to the valence shell.

Part (b) (i) and (ii) required candidates to state (i) ONE similar property, and (ii) ONE different property of X and Y.

Many candidates were able to state correctly that both elements would be solids.

Common Incorrect Responses

Similar physical property for X and Y:

- They have the same number of shells.
- They have the same number of electron rings.
- They are liquids.

Different physical property for X and Y:

- They have different number of valence electrons.
- They will be in different states.

Expected Responses

Candidates were expected to suggest physical properties of X and Y, based on their positions in the Periodic Table.

Similar property: Both X and Y are solids. Also accepted that Y could be a liquid or gas. X is in Group 2, and is therefore a metal, so any property that is suggestive of a metal is accepted.

Different property: Some properties accepted were melting point, boiling point, density – with the property of X being greater than the property of Y. Also accepted – X is shiny and Y is dull; X is a metal and Y is a non-metal (which suggests that X is metallic in character while Y is non-metallic).

Part (c) (i) required candidates to state the type of bonding that would occur between phosphorus, P and Element Y.

The majority of candidates correctly stated that the bonding would be covalent.

Part (c) (ii) required candidates to sketch a diagram showing the bonding between P and Y.

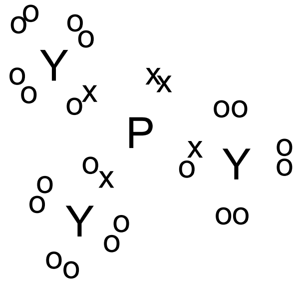
Some candidates had difficulty producing diagrams with the correct number of valence electrons on both P and Y. However, the majority recognized that one atom of P would bond to three atoms of Y.

Common Incorrect Responses

A number of candidates drew diagrams depicting ionic, rather than covalent bonding, with the transfer of three electrons from one atom of P to three atoms of Y, or with the transfer of electrons from three atoms of P to three atoms of Y.

Expected Responses

The correct diagram showing covalent bonding between P and Y is:



The electrons on P are represented by 'x' and the electrons on Y are represented by 'o'. Each atom now has eight electrons, that is, a stable octet of electrons, around it.

In Part (c) (iii), candidates were required to write the chemical formula of the compound formed between P and Y, and suggest two properties of this compound.

A number of candidates showed the correct bonding diagram.

Common Incorrect Responses

- High melting point
- High boiling point
- Conducts electricity in the molten state
- Soluble in water

Expected Responses

Based on the bonding diagram shown above, the formula of this compound is PY_3. General properties of simple-molecular covalent compounds include:

- Low melting point
- Low boiling point
- Insoluble in water
- Soluble in non-polar (organic) solvents
- Does not conduct electricity in solution. (However, some compounds may decompose in water to give ionic species. Such solutions will conduct electricity.)

<u>Question 3</u>

Syllabus References: B1: 3.3, 3.7, 3.8, 4.2, 4.3, 4.4, 4.6

This question tested candidates' knowledge of the petroleum industry, addition and condensation polymerization, and the acid hydrolysis of proteins.

In Part (a), candidates were required to explain what is meant by cracking, a process that is very important in the petroleum industry.

More than 50 per cent of candidates were able to correctly indicate that cracking involves the breaking up of long chain hydrocarbons into shorter chains.

Common Incorrect Responses

Some of the misconceptions of candidates regarding this part of the question were evident in their explanation of cracking as (i) a method of separation or (ii) a method of obtaining oil from the earth. Some candidates replaced the term hydrocarbon with units, atoms, particles, elements or substances.

Expected Responses

Cracking is the process by which <u>hydrocarbons in the heavier fractions</u> produced by fractional distillation of crude oil are <u>broken down into lower molecular weight hydrocarbons</u>.

In Parts (b) (i), candidates were required to draw a structural representation of a monomer of glucose.

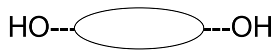
Instead of drawing a 'structural representation' of a glucose monomer, the majority of candidates attempted to draw a molecule of glucose. This was not required. A common error in this question was drawing carbon with fewer than four or more than four bonds.

Common Incorrect Responses

Many candidates showed a poor interpretation of the formula and drew incorrect straight chain structures, attempting to incorporate 6 carbons, 12 hydrogens and 6 oxygens into the structure.

Expected Responses

The correct structural representations of a glucose monomer can be shown as:

- HO – X – OH
- 

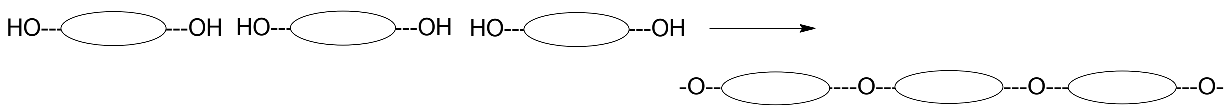
where the two OH groups, that will be used in polymerization, are shown.

In Part (b) (ii), candidates were required to use THREE units of the glucose monomer to show how the monomers are linked together in a partial structure of starch.

This was a challenging area for candidates. Many were unable to draw the polymer since they had little knowledge of the structure of the monomer, or the representation of the monomer unit. Many candidates were unsure as to how to eliminate the water molecule. A common error in this question was that many candidates treated the reaction as an addition polymerization rather than a condensation polymerization reaction.

Expected Responses

The equation of the reaction, using the three units of glucose is:



where condensation has taken place, and a molecule of water is removed from between adjacent monomer units.

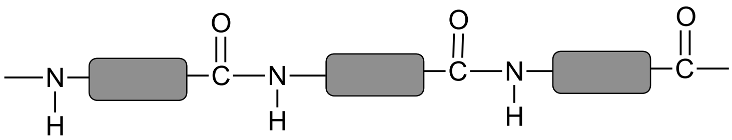
Part (b) (iii) required candidates to state the type of polymerization that glucose undergoes to form starch, and to name the family of polymers to which starch belongs.

Most candidates correctly stated *condensation polymerization* and *polysaccharides* as the answers and were credited the marks.

Common Incorrect Responses

Type of polymerization:	Addition polymerization
Family of polymers:	Carbohydrates

In Part (c), the partial structure of a protein molecule was given as



Candidates were required to describe how the structure of the protein is affected by acid hydrolysis.

The majority of candidates scored no marks for this part. Several candidates were able to say that bonds are broken, but could not identify the type of bond. Those candidates who received at least one mark were able to recognize that amino acids were produced or drew the peptide link and drew a line showing where the bond is cleaved.

Common Incorrect Responses

- This causes the structure of the protein to break apart.
- Water is added to the structure.
- The protein is broken down.
- The products of hydrolysis are a diacid and a diamine.

Expected Responses

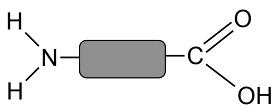
Candidates should refer specifically to what happens to the peptide linkage, -CONH-. Acid hydrolysis of proteins results in the cleavage of the peptide bond, and this produces amino acids.

In Part (c) (ii), candidates were required to draw the structure of the monomer unit that results from the hydrolysis of the structure shown above.

Many candidates realized that the protein would be broken into monomer units, but were unable to draw the two functional groups.

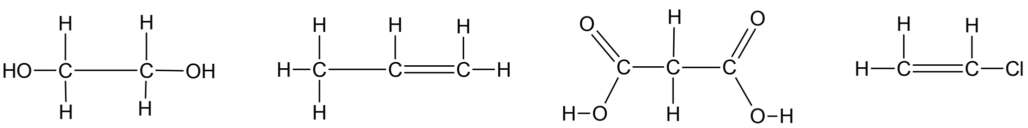
Expected Responses

The structure of the amino acid, monomer unit is



Where an atom of H is added to the nitrogen to form an amino group, $-NH_2$, and an OH group is added to the carbon to form the carboxylic acid group.

In Part (d), the structures of four different monomers, P, Q, R and S, were given.



P **Q** **R** **S**

In Part (d) (i), candidates were required to identify two monomers that would undergo condensation polymerization, and one that would undergo addition polymerization, selecting from the four given.

The majority of candidates were able to correctly identify these monomers.

Expected Responses

The two monomers that will undergo condensation polymerization are P and R. A monomer that will undergo addition polymerization is either Q or S.

Part (d) (ii) required candidates to state the name of the family of polymers that would be formed when monomers P and R reacted together. While many candidates gave the correct name, some were incorrect.

Common Incorrect Responses

Esters
Esthers

Expected Response

The correct name is *polyesters*.

Question 4

Syllabus References: A: 6.27, 7.2, 7.3, 7.4; B2: 5.2

This question was designed to test candidates' knowledge of factors that affect the rate of reaction and of the uses of metal alloys.

The performance of the candidates on this question was fairly satisfactory since the majority of the candidates scored between 6 and 9 marks. In particular, the parts of the question that involved mole calculations and the determination and description of an appropriate laboratory procedure proved challenging for most candidates.

Part (a) of the question was generally well done, with most of the candidates obtaining all 4 marks for stating any four of the following responses: concentration of reactants, pressure, temperature, particle size or surface area, catalyst, light.

Common Incorrect Responses

Many of the weaker candidates erroneously included solubility and pH as factors affecting rate of reaction.

Part (b) (i) proved challenging for a number of candidates who either experienced problems reading the scale on the y/volume axis or who did not know how to determine the total volume of CO_2. The expected volume was **124 cm^3.**

Part (b) (ii) posed some difficulty to candidates who could not accurately convert volume of CO_2 to moles and then relate this to mass of $CaCO_3$ as shown below:

Moles of CO_2 = 124/24000 = 0.0052 moles = moles of $CaCO_3$
Mass of $CaCO_3$ = 0.0052 × 100 = 0.52 g

Part (b) (iii) was fairly well done, although it was noted that several candidates did not know how to interpret the graph to determine the total volume of gas. This seems to suggest a lack of experiential knowledge of how such data may be generated.

Common Incorrect Responses

- The total volume of CO_2 formed in Part (i) was incorrectly interpreted. Candidates summed the volumes at each point on the curve instead of reading the volume at the flat part of the curve.
- Some candidates were confused about the concept of **small** particle size corresponding to **large** surface area and vice versa.
- Another common misconception displayed by many candidates was the incorrect use of the terms ‘dissolve’ or ‘mix’ to mean ‘react’ in their description of the experiment.

Expected Responses

The expected answer for Part (iii) was *rate of reaction will increase since the surface area increases or particle size decreases* or alternatively *time will decrease since the rate of reaction increases.*

For Part (c) (i), the responses showed that candidates generally understood that *alloys have improved properties and greater flexibility of use or function over the pure metal(s)*. The weaker candidates misinterpreted the question and listed properties of pure metals instead.

Part (c) (ii) proved to be the most difficult part of the question for candidates, who mostly gave no response or responded with incorrect laboratory procedures.

Stimulus material given in the question ‘manganese is above hydrogen in the electrochemical series’ guided a minority of candidates to the correct procedure for obtaining a sample of dry copper from a sample of the alloy other than electrolysis as stated below on the expected response.

However, many of these candidates failed to include wash/rinse the residue and therefore lost one mark.

Some candidates also spent valuable time unnecessarily explaining the theory for copper not being able to react with acid instead of detailing the laboratory procedure, while others described the process of electrolysis for the extraction of copper from alloys even though the question indicated ‘other than electrolysis’.

Expected Responses

- Allowing a sample of the alloy to react with excess dilute acid
- Filtering the resulting mixture and collect the residue
- Washing with water and dry in air/oven to obtain copper

Common Incorrect Responses

- Incorrect procedures, such as fractional distillation, use of a magnet or mixing with water to separate copper
- Correctly adding acid to alloy but erroneously crystallising a copper salt from the filtrate

<u>Question 5</u>

Syllabus References: A: 6.23, 6.24, 6.25, 6.27, 6.28, B2: 3.1, 5.2

This question examined the candidates’ knowledge of electrolysis of concentrated sodium chloride and copper(II) sulfate solutions.

Part (a) of the question tested candidates' knowledge of the industrial preparation of chlorine by electrolysis, using the ion exchange membrane cell. In (a) (i), candidates were required to give the name of the electrolyte and the ions present.

The majority of candidates were specific and stated that the electrolyte was concentrated sodium chloride. However, some candidates named the ions from the salt, but did not name the ions from water. Sodium chloride or aqueous sodium chloride was not accepted, since the products of dilute and concentrated sodium chloride are different.

Common Incorrect Responses

Electrolyte:

- Molten NaCl
- Aqueous NaCl
- NaOH
- HCl
- Ions in solution:
- Na^{2+}, Cl, H, Cl^{+}

Expected Responses

The electrolyte is *concentrated* sodium chloride and the ions are Na^{+}, H^{+}, Cl^{-} and OH^{-}.

In Part (a) (ii), candidates were required to provide an explanation for which ions are preferentially discharged at the electrodes. The less than satisfactory performance was due mainly to the incomplete and superficial responses alluded to earlier in the report. Many candidates stated that the reason was the position of the ions in the electrochemical series but did not give the relative positions of the ions in the series. Some candidates knew the factors used to decide preferential discharge but did not identify the ions as H^{+} and Cl^{-}. Others confused the electrochemical and reactivity series, incorrectly assuming that they were the same.

Common Incorrect Responses

- Cations move towards the cathode and anions move towards the anode.
- Sodium is more reactive hence it is discharged first.

Expected Responses

At the cathode, the H^{+} ion is discharged in preference to the Na^{+} ion. For the positive ions, the one that gets discharged at the cathode is the ion of the least reactive metal/element. This occurs because least reactive elements have a greater tendency to be atoms or the more reactive metals have a greater tendency to be ions rather than atoms, therefore, ions like Na^{+} and K^{+} are NOT preferentially discharged.

Part (a) (iii) required candidates to write ionic equations for the electrode reactions. Approximately 50% of candidates wrote the correct equations showing the formation of hydrogen gas and chlorine gas at the cathode and anode respectively.

Common Incorrect Responses

Common incorrect responses showed the incorrect species of the electrons being discharged on the wrong side of the ionic equations. Some equation showed 'ions' without charges, that is, atoms being discharged, instead of ions.

Anode reaction:

- $Na^{+}(aq) + e^{-} \rightarrow Na(s)$
- $2H^{+} \rightarrow H_2 + 2e^{-}$

Cathode reaction:

- $4OH^{-} \rightarrow O_2 + H_2O + 4e^{-}$
- $2Cl^{-} + 2e^{-} \rightarrow Cl_2$

Expected Responses

Anode reaction: $2H^{+}(aq) + 2e^{-} \rightarrow H_2(g)$

Cathode reaction: $2Cl^{-}(aq) \rightarrow Cl_2(g) + 2e^{-}$

Part (c) (iv) required candidates to state the role of the ion exchange membrane. This part was poorly done and candidates seemed unfamiliar with the content. Some candidates incorrectly referred to the membrane as semi-permeable.

Expected Responses

In this cell, the ion-exchange membrane that is positioned between both electrodes separates Cl^{-} ions from OH^{-} ions. When the solution is added to the membrane, the membrane allows Na^{+}, H^{+} and OH^{-} ions to pass to the cathode chamber and Cl^{-} stays in the anode chamber. Cl^{-} is discharged, while the OH^{-} is trapped in the cathode chamber and cannot pollute the chlorine gas being collected. H^{+} is discharged at the anode and collected. Na^{+} and OH^{-} bond together, forming sodium hydroxide which is extracted from the bottom of the cathode chamber.

In Part (b), an experiment was carried out to purify copper by electrolyzing copper(II) sulfate solution using impure copper as the anode and pure copper as the cathode.

Part (b) (i) required candidates to state what was expected to happen at the anode during the experiment.

This part was well done and most candidates recognized that the anode would decrease in size.

Common Incorrect Responses

- The anode would increase in size.
- The copper would deposit below the anode.
- Impure copper will be discharged.
- Impurities will fall off leaving the pure copper behind.
- The anode will melt/break off.

Expected Responses

The anode will decrease in size. This happens as the copper atoms from the anode are oxidized and go into solution.

In Part (b), candidates were required to calculate the mass of pure copper that would be produced during the experiment if a current of 5 A flows for 30 minutes. This part was fairly well done. A common error was not converting the minutes to seconds.

Common Incorrect Responses

Most of the incorrect responses did not account for the 2:1 mole ratio as shown in the equation below.

Expected Responses

The equation of reaction: $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

2 mol 1 mol

2 × 96 500 C 64 g

Amount of charge, Q = I × t = 5 A × 30 × 60 s = 9 000 C

2 x 96 500 C produces 64 g of copper
9 000 C produces 64 g × 9 000 C / (2 × 96 500 C) = 2.98 g of copper

Question 6

Syllabus References: C1: 2.5, 2.6, 2,7, 2.10

Part (a) (i) – (ii)

Generally, candidates performed well on this task.

Part (a) (i) required the candidates to name the main pollutants that are responsible for ozone depletion and global warming. Many candidates identified the sources of the pollutants, such as 'burning of fossil fuels' and 'aerosols', rather than the pollutants themselves. The response 'aerosols' was not credited but credit was given for *'CFCs'*. Some candidates wrongly identified 'CO_2' as the pollutant for both ozone depletion and global warming. Candidates who stated both answers together without linking to either ozone depletion or global warming were not credited.

Part (a) (ii) required the candidates to name TWO harmful effects of ozone depletion and global warming.

Common Incorrect Responses

- Many candidates named only two harmful effects and did not link either of the effects to ozone depletion or to global warming.
- Candidates stated that the effect of increased CO_2 levels resulted in a decrease in O_2 levels.
- Ozone depletion resulted in global warming.
- Ozone depletion led to UV radiation entering the Earth's atmosphere rather than it leading to an INCREASE in penetration of UV radiation.

Responses that were credited include:

- Ozone depletion leads to *increase in skin cancer*, *reduced immune function* or *death of phytoplankton*.
- Global warming leads to *melting of polar ice caps*, *rising sea levels*, *more severe storms/ hurricanes* and *severe drought*.
- A simple statement of 'climate change' **was not credited**.

Full marks were awarded for the following response to Part (a) (ii).

> *Two harmful effects of ozone depletion are (i) increased UV radiation, which will lead to an increase in skin cancers, (ii) the melting of the icecaps at a faster rate, which will contribute to rising sea levels.*

Part (b) (i) – (ii)

Part (b) (i) required the candidates to suggest TWO ways a hotelier could 'go green' in addressing water use. The major weakness in responses that were not credited was the fact that candidates failed to develop points made. For example, candidates who suggested that water can be 'conserved' without stating how this can be done were not awarded any mark for that response. However, responses that were credited include:

- *The hotelier can advise guests to turn off the taps while brushing teeth.*
- *The hotelier can install taps with sensors or with timers.*
- *The hotelier can use water from the kitchen to water plants.*

Part (b) (ii) required the candidates to suggest TWO ways a hotelier could 'go green' in addressing garbage disposal. Again vague responses such as 'Proper disposal, 'Do not litter', 'Send to a sanitary landfill' and 'Bury instead of burning' were not credited. However, more specific responses were, for example:

- *The hotelier can install recycle bins and encourage guests to use them.*
- *The hotelier can compost vegetable matter from the kitchen to use as fertilizer on the plants.*
- *The hotelier can use more biodegradable products instead of plastics.*

Part (b) (iii) required the candidates to suggest TWO ways in which a hotelier could 'go green' in addressing energy use. Most candidates earned marks for naming one alternative source of energy, for example: *Use a solar water heater* or *Switch to energy-saving light bulbs* or *The hotelier can advise guests to turn off lights and air-conditioners when leaving the room*. Candidates who simply stated *Conserve energy* were not credited.

Part (c) required candidates to state their opinion on the setting up of common international standards for pollution control and TWO points to support such a position. While most candidates were able to obtain marks for stating an opinion, many did not go on to give support to the opinion stated but rather stated the effects of pollution.

Examples of points to justify common international standards for pollution control included:

- Pollution is a global problem and should be dealt with in a global way.
- Pollution produced in one country can affect other countries.
- There is a serious need for countries to work together to reduce the level of pollution.

Examples of points AGAINST common international standards for control included the following:

- Poorer countries would not be able to afford the cost of meeting these standards.
- All countries do not have the same problem with pollution and may not need these standards.

Paper 032 – Alternative to SBA

Question 1

Syllabus references: A: 3.3; 8.1; 8.3

The maximum marks available were 25. The highest mark achieved was 23 but the majority of the candidates obtained between 7 and 13 marks.

This question tested the candidates' knowledge of reactions of metals and acids, their ability to test for the gas produced as well as their knowledge of its physical properties. In addition, the ability of candidates to plot a graph and describe its shape, calculate moles from mass and the chemical equation and volume from molar volume, write a possible aim and identify variables was also tested.

Most candidates read the scale and knew how to plot the points on the graph correctly; however, many of them did not draw the smooth curve that was expected. Some candidates plotted the points only and others used a ruler to join the points. Candidates should be reminded that plotting a graph includes drawing the best fit line or curve as well.

Generally, the balanced chemical equation was well done but a few candidates did not know the correct chemical formula for magnesium chloride, $MgCl_2$. In a few cases, the charge of the metal was placed in the equations. Candidates should be reminded that charges are not part of the chemical equation unless the reactants or products are ions.

In Parts (iii) and (iv), candidates were asked to describe the general shape of the graph and to account for the shape. Some candidates accurately described the shape as a curve but sloping upwards – this was also accepted. However, accounting for the shape proved problematic for most of the candidates. Many candidates obtained one mark for stating that the longer the ribbon the more time was needed for the reaction to be completed but they neglected to include the fact the concentration of the acid was not changed or remained constant for the second mark.

For the calculations, most candidates were able to obtain 2 of the 3 available marks for calculating the mass of the 9-cm length of magnesium ribbon and changing the mass to moles. However, many neglected to use the mole ratio from the equation when trying to calculate the moles of acid that would react with it. In addition, many of the candidates knew to multiply the moles of magnesium by 24 to find the volume of gas but some used the moles of acid instead and many did not know the correct units.

When asked to suggest a possible aim for the experiment in Part (b), the language used was unsatisfactory. Many candidates did not include the terms 'to determine', 'to investigate' or 'to find'. Many answers were in the form of a statement for example 'measure the volume of gas produced' or 'measure the rate of reaction'. Some correct responses were 'to determine the rate of reaction between magnesium and HCl' or 'to determine the rate of production of hydrogen for the reaction'.

The variable to be controlled was either the mass of magnesium or the volume of acid. Temperature was also accepted. Candidates should be encouraged to use correct terms of measurement that are scientifically accepted with their units, for example, volume (cm^3) or mass (g) and not use the term 'amount' which has no units. The acceptable variables to be measured were the volume of gas produced and the time taken.

Many candidates confused the test for hydrogen gas with that of oxygen gas. In many cases, using a glowing splint was suggested instead of a lighted splint. However, whether the splint was lit or was glowing most of the candidates expected to hear the 'pop'.

Many candidates did not earn the mark for deducing the physical property of the gas produced in the experiment. Many candidates noted that the gas was less dense than air but this was not accepted because it could not have been deduced from the experiment. Since the gas was collected over water some of its acceptable physical properties were that it was less dense than water, insoluble in water or even colourless.

When candidates were asked to write an observation when the concentration of HCl was doubled, many stated that the rate of reaction was faster. This was not accepted since rate is not simply observed but must be calculated. Acceptable responses included *more bubbles were observed in less time*, *magnesium dissolved faster* and *more effervescence was seen*.

Many candidates were unaware that once the reaction had ceased then the acid was completely used up or that the magnesium ribbon was in excess. In addition, many candidates assumed that the resulting liquid would have been either acidic (reacting with blue litmus only) or basic (reacting with red litmus only). Very few candidates recognized that it would have been neutral, reacting with neither blue nor red litmus paper.

Question 2

Syllabus references: B2: 7.1, 7.2 and 7.3

Overall, this question was poorly done, with approximately 70 per cent of the candidates scoring 4 or less of the maximum 10 marks. This question focused on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid, Compound P, as well as its aqueous solution.

Again, it appeared that the majority of the candidates were not familiar with qualitative analysis, the tests as well as generally making observations. For example, when told that after heating a portion of P the gas was tested with a glowing splint and was confirmed to be oxygen, many candidates did not know that oxygen would relight the glowing splint or that oxygen would be colourless. Many candidates did recognize that Al^{3+}, Pb^{2+} and Zn^{2+} would give a white precipitate in sodium hydroxide and Zn^{2+} in aqueous ammonia but they did not know that in both cases the precipitate would be soluble in excess. Some candidates knew that a pale yellow precipitate is observed when I^- ions react with $AgNO_3$ but they didn't seem to know that it would be insoluble in excess aqueous ammonia. However, most candidates did know that NO_2 is a brown gas.

Question 3

Syllabus reference: A 6.25

This question tested the candidates' planning and design skill and was poorly done, with about 70 per cent of the candidates earning 4 or less of the maximum 13 marks.

Less than half of the candidates wrote an acceptable aim – many simply rewrote the hypothesis. Many excluded the required variables which were the change in mass of the copper cathode and the different concentrations of the copper(II) sulfate solution.

Not many candidates provided the essential apparatus required to carry out the experiment. The weighing apparatus was excluded from many of the responses. In addition, candidates needed to be more specific in listing appropriate apparatus required for electrolysis.

In many instances, candidates did not relate the procedure to the hypothesis. Many did not recognize that they had to weigh the cathode before and after the electrolytic process as well as vary the concentration of the electrolyte. It was evident that some candidates were never exposed to the process of electrolysis.

Most of the candidates, however, were able to state at least one variable to be controlled in the experiment (that is, time or temperature) so this part was done fairly well. Some also recognized that there was something about the $CuSO_4$ that needed to be controlled but rather than being specific and noting that the volume of the $CuSO_4$ should be controlled some simply wrote the $CuSO_4$ solution. Most candidates stated the mass of the copper cathode as data to be collected but many did not recognize that they also needed to state the varying concentrations of the $CuSO_4$ solution as well.

Candidates did not relate the discussion to the hypothesis. It was expected that candidates would identify under which circumstances the hypothesis would be accepted and under which circumstances it would be rejected. Many candidates who attempted the question only noted when it should be accepted.

Many candidates were not able to recognize the possible sources of errors that may occur during the experiment. Accepted answers were *fluctuations in the current* or *temperature*. Human errors and parallax errors were not accepted as sources of errors for this experiment.

Paper 031 – School-Based Assessment

Planning and Design (PD) Skill

Generally the standard of the laboratory exercises assessed for the Planning and Design skill has declined again this year. Teachers and students are urged to consult the June 2012 CSEC Chemistry Subject Report for detailed information regarding the standard and structure expected of the PD labs. In addition, there are 13 suggested PDs for teachers to utilize freely, with details on two of them as examples.

At the same time, teachers are reminded of the following:

- All PD activities should be based on chemical concepts included in the syllabus. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition or any other non-chemistry discipline cannot be accepted.
- Students should undertake at least four PD activities over the two-year period. When this is not done the students are at a disadvantage.
- Some SBA Planning and Design activities were assessed for other skills as well. This suggests that the exercise has been carried out and so cannot be moderated for PD skills. This places the candidates at a serious disadvantage.
- While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does suit all the PD activities submitted. If not, then each PD activity should have a separate mark scheme.
- Ensure that the problem statement is written on the mark scheme and that the students include it in their laboratory books before submission.
- Students should be encouraged to state the variables (control, manipulated) separately and not just have them in the method.
- Students should also be encouraged to review their method to ensure that all the necessary apparatus and materials are listed. One way in which this could be done is to have them write the method before listing the apparatus.

Analysis and Interpretation (AI) Skill

The Analysis and Interpretation skill continues to be one of the skills on which students demonstrate greater proficiency. In general, the calculations were well done; however, there appears to be a decline in the number of qualitative analysis experiments to which the students are being exposed. This lack of exposure may place the students at a disadvantage and this was also evident in the Alternative to SBA paper.

In order to encourage continual improvement here are a few points to note:

- Samples **should not be submitted** without mark schemes.

- Students should be required to complete their table of contents. This should include the experiment number (corresponding with the mark scheme), the date the experiment took place, as well as its pagination. Keeping good updated laboratory books is a practice that should be encouraged among all aspiring chemists.

- Teachers should spend time developing good analytic rubrics (mark schemes) to accompany the laboratory exercises. Once developed, these can be simply adjusted as changes are made to the exercises.
    - In the case of volumetric analysis, the concentration of reagents being used should be provided in the mark scheme.
    - In the case of qualitative analysis, the name of the unknown or the ions expected should also be included in the mark scheme.
    - If there is more than one teacher at the centre, the teachers should collaborate and submit one common mark scheme.
    - When interpolation from a graph is marked for AI skill the mark schemes need to be more explicit to guide the moderation process.
    - When requiring a balanced chemical equation, teachers are advised to award a maximum of 2 marks. One mark should be awarded if it is unbalanced.
    - Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should not be assessed under AI.
    - Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected by the teacher.
    - Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that the student understands what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again, teachers are asked to refrain from using the equation $M_1V_1=M_2V_2$.
    - Teachers should insist that students write correct formulae: for example, sodium chloride as NaCl and not NaCL and Mg not mg for magnesium.
    - Students require more guidance in producing the discussion section of the laboratory report. Perhaps teachers can ask specific questions which will assist students in this section. These questions should be included in the mark scheme to guide the moderation process.
    - When assessing a laboratory exercise for more than one skill, both skills should be clearly stated with their marks separately noted.