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 2012

CHEMISTRY
GENERAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

The overall performance of candidates in the 2012 examination was slightly below that of previous sittings. Candidates performed best on Questions 4 and 6. The topic Pollution and the Environment was tested for the first time. There were no questions on which some candidates did not obtain full marks. From year to year, the report on performance in the CSEC examination highlights the areas that candidates seem to find difficult as well as the kinds of errors that they make. Yet, these weaknesses persist. Again, this report highlights the strengths and weaknesses in candidates' performance in the examination. Teachers and students are encouraged to use the information presented here to self-assess and so better prepare for the examination.

Areas of Strength

Candidates performed fairly well in the following areas:

- Plotting points on a graph
- Factors that affect the rate of chemical reaction
- Redox processes that take place at the electrodes
- Some definitions, for example, oxidation and reduction and hard water
- Calculation of the quantity of electricity that passes through an electrolytic cell given current and time
- Homologous series for hydrocarbons
- Organization of elements in the Periodic Table
- Factors that cause corrosion
- Properties of water
- Strategies that can be used for preserving the environment

Areas of Weakness

Candidates performed poorly on the following topics:

- Electrochemistry
- Qualitative analysis

Factors Contributing to Poor Performance

- Writing and balancing equations and use of the correct mole ratio

  – Candidates were required to write chemical equations in all questions except Question 6. The major weakness was the incorrect formulae used throughout which stemmed from incorrect valencies. As a result, formulae were incorrectly written in equations resulting in marks being lost.

  – Candidates' failure to use the correct mole ratio when solving problems for Questions 1 and 2 also led to the loss of marks.

- Superficial rather than critical level of understanding of concepts

  – This was evident in the inability of candidates to provide the right reason for the claims made. For example, candidates lost marks because they could not provide a correct reason for the differences and similarities in the two graphs for the marble chips and powdered calcium carbonate in Question 1. Candidates seemed not to know how to select the required content to answer questions from their knowledge base. Perhaps candidates need to be provided with more practice to answer questions that require analysis and explanations so as to improve their critical thinking skills.

– The tendency to be superficial in responses was also noted in the types of errors that candidates made. It was clear that many had an idea of the area but lacked the specific knowledge to provide complete or correct responses. For example, in Question 2, many candidates mixed up the changes required for the anode and the cathode in order to obtain pure copper from impure copper although they were credited marks for the changes required for the electrode. This weakness was also evident in the diagrams drawn for Question 1, and the general formulae for alkenes and alkanes in Question 3. The recommendation made in previous reports is worth repeating here. Teachers should engage students in developing deep and enduring understanding of concepts by using strategies that help students to connect ideas and understand principles. Classroom conversations on concepts should be encouraged and the correct use of terms during classroom conversations should be the norm. In addition, it is important that students be provided with visual images to represent concepts, for example, general formulae, dot-cross diagrams and arrangements of apparatus for experimental procedures.

– There is also a tendency to use terms loosely. For example, candidates referred to the corrosion of aluminium as rust, iron(III) ions as iron, and electrochemical series as reactivity series.

- Limited Understanding of Practical Procedures

  – It appeared that candidates were unfamiliar with conducting qualitative analysis and performed unsatisfactorily on Question 1.

  – Other practical procedures required in parts of Questions 2, 3 and 4 also proved to be challenging and too many candidates lost marks for these areas.

DETAILED COMMENTS

Paper 01 — Multiple Choice

This paper tested Sections A and B of the syllabus in the Knowledge and Comprehension profile dimension. Performance on this paper continues to be steady and satisfactory. The marks ranged from 0 to 60. The mean score was 51.5 per cent and the standard deviation was 11.39.

Candidates experienced the most challenges with items based on the following objectives:

- A.1.2 – Differences among the three states of matter
- A2.5 – Notation representing mass number, atomic number, oxidation number
- A.5.3 – Solubility of solids in water
- A.6.10 – Salt preparation based on solubility of salt
- B1.2.7 – Reaction of ethanol
- B2.1.2 – Reactions of metallic carbonates
- B2.4.2 – Order of reactivity

Paper 02 – Structured Essays

Question 1

Syllabus References: A: 7.1, 7.7, 7.3, 7.4; B2 7.1, 7.2, 7.3

Part (a) (i) tested candidates' knowledge of experimental procedure for collecting and measuring the volume of gas generated during a chemical reaction. Candidates were required to draw a suitable diagram for the reaction between dilute nitric acid and calcium carbonate, and for measuring the volume of gas (carbon dioxide) generated.

Most candidates attempted this section, but many diagrams were poorly drawn. This was mainly due to the following flaws:

- The experimental apparatus was not airtight making it impossible to collect the gas.
- The delivery tube did not extend into the reaction flask to allow for efficient collection of the gas.
- Many candidates drew diagrams of the distillation apparatus.
- There was no evidence of how the volume of gas could be measured.

Candidates were expected to draw a diagram showing a delivery tube above the reaction mixture in an airtight container and connected to a graduated gas syringe to measure the volume of gas to be collected.

In Part (a) (ii), candidates were required to plot the points obtained for the reaction of marble chips and dilute acid, using the same axes as for the powdered calcium carbonate which was already drawn. Candidates generally performed well, in that a significant number plotted six points accurately and most were able to get at least two of the three marks for this section.

The points that most candidates found difficult to plot were those for 30, 70 and 90 s. In some cases, the plotting of points, although accurate, were not done neatly. For example, large dots and asterisks were sometimes used. In a few cases, candidates drew the best-fit curve without plotting all points although this was not what the question required.

Part (a) (iii) tested candidates' ability to compare the two graphs for the reaction of marble chips and powdered calcium carbonate with dilute acid (in terms of steepness of the curves and the total volume of gas) and to account for the similarities and differences.

Most candidates were able to earn at least one mark here as they were able to identify similarities and/or differences in the two graphs. They were able to determine the steepness of the curves, relating this to the rate of the reaction and correctly identified the graph with the steeper slope as having the faster rate. However, many candidates were unable to provide correct responses for the similarities and differences.

In many responses, candidates gave the impression that powdered calcium carbonate and marble chips were different compounds. In looking at similarities, some candidates mentioned that both reactions had the 'same end point' rather than stating that the *same volume of gas was produced at the end of each reaction*.

The expected similarity in the two graphs was the *total volume of carbon dioxide produced was the same for powdered calcium carbonate and marble chips*. The expected reason was *the mass of calcium carbonate used was the same for both reactions*.

The expected difference was *the graph for the reaction with powdered calcium carbonate had a steeper slope than that for marble chips at the start of the reaction*. The reason being that *the rate of reaction for powdered calcium carbonate was faster and/or the total surface area of the powdered calcium carbonate was greater than that of marble chips*.

For Parts (a) (iv)–(v), candidates were required to write a balanced equation for the reaction between calcium carbonate and nitric acid and to calculate the theoretical yield of carbon dioxide from 1.8 g of calcium carbonate at RTP.

Most candidates were able to write the required equation but far too many were unable to write the correct formula for calcium nitrate and so did not produce a balanced equation. Candidates performed the calculation fairly well and were able to calculate correctly the molar mass provided they had the correct formula. However, they lost marks for failure to relate the number of moles of carbon dioxide to the number of moles of calcium carbonate.

Common Errors and Incorrect Responses

- Formula for calcium nitrate was commonly written as '$CaNO_3$'.
- Molar mass of calcium carbonate calculated as 68 by adding the atomic masses of calcium, carbon and oxygen without regard to the number of each element (40 + 12+ 16) or 84 — by using the incorrect formula ($CaCO_2$) for calcium carbonate.
- In a few cases, hydrogen gas was indicated as a product.
- Some candidates used the mole ratio between $CaCO_3$ and HNO_3 in their calculations instead of $CaCO_3$ and CO_2.
- They also wrongly found use for Avogadro's constant.
- Many incorrect statements were used in the calculations. For example, candidates inferred that the gas formed was calcium carbonate.

The expected balanced chemical equation for Part (a) (iv) was

$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$.

The expected calculation for Part (a)(v) was

Number of moles of $CaCO_3$ used was 1.8/100 = 0.018 moles
From equation: 1 mole $CaCO_3$ produced 1 mole CO_2
Therefore: 0.018 moles $CaCO_3$ will produce 0.018 moles CO_2 gas
1 mole of a gas occupies 24 000 cm^3
Therefore, 0.018 moles of CO_2 formed will occupy 0.018 x 24 000 cm^3 = 432 cm^3.

In Parts (a) (vi)–(vii), candidates were required to provide an explanation for the difference in the theoretical yield of 432 cm^3 and the actual yield of 370 cm^3, and to state two factors other than particle size that could affect the rate of reaction between the calcium carbonate and dilute acid.

Very few candidates were able to provide a suitable explanation for the difference between the theoretical and actual yields of carbon dioxide. Candidates were not awarded marks for sources of error that could have been due to faulty technique over which there was control. Most candidates were able to state one other factor that would affect the rate of reaction.

Most candidates identified temperature as another factor that could affect the rate of reaction.

Common Incorrect Responses

Common incorrect responses that were not awarded marks were:

- parallax errors
- failure to measure the gas accurately
- time and pressure.

In Part (vii), candidates were not credited for mentioning surface area as the question informed them that the investigation dealt with particle size. Many candidates suggested light — even though the reaction is not a photochemical reaction — and pressure — even though neither of the reactants was in the gaseous state.

Candidates were expected to state factors such as temperature and concentration of the nitric acid.

Part (b) tested candidates' knowledge of the tests for common cations and anions. The cation was iron(III) ions and the anion, the chloride ion. Candidates were required to deduce the correct observations and inferences based on either the stated observation or inference given.

Candidates performed poorly on this part, with most of them scoring three or fewer marks from the total of eight.

Common Incorrect Responses

- Test (i) — candidates inferred the presence of Fe^{2+}, Pb and Br instead of Fe^{3+}.
- Test (ii) — candidates indicated the formation of a white precipitate and disintegration of magnesium.
- Test (d) (iii) —– candidates had difficulty writing a balanced ionic equation. Their attempts revealed incorrect state symbols and incorrect placement of charges.
- Test (iv) — the candidates inferred the presence of halide ions and some recognized the absence of only one of the possible three anions that were absent.
- Test (v) — candidates suggested yellow precipitate which was insoluble in excess aqueous ammonia and white fumes.

<u>Question 2</u>

Syllabus References: A: 6.14, 6.15, 6.18, 6.24, 6.25, 6.27, 6.28

This question was based on a diagram depicting the electrolysis of aqueous copper(II) sulfate, using platinum electrodes. Candidates performed below a satisfactory level on this question.

In Part (a), candidates were required to determine the oxidation state of sulfur in $CuSO_4$. Many candidates were able to correctly deduce the oxidation state of sulfur in the compound as +6. However, a considerable number gave –1, 16, +4, –2 and –8.

For Part (b) candidates were told that hydroxide ions were discharged in preference to sulfate ions at the anode for this electrolytic experiment. They were expected to state a reason for this.

Many candidates were able to state correctly that the hydroxide ions are lower in the electrochemical series than sulfate ions. Some candidates, however, incorrectly suggested that the hydroxide ions are higher than the sulfate ions in the electrochemical series.

Part (c) required candidates to write a balanced equation for the reaction occurring at the anode of the electrolytic cell.

Although some candidates were able to write the correct half equation for the discharge of the hydroxide ion at the anode, it seemed as though many candidates were unfamiliar with the ionic half equation required or even the use of ionic half equations as electrodes of electrolytic cells.

Common Incorrect Responses

$4OH^- - 2e^- \rightarrow 2H_2O_2$
$CuSO_4 + OH \rightarrow Cu_2OH_4 + SO$
$SO_4^{2-} + 2e^- \rightarrow SO_4$

In Part (d), candidates were required to state whether the reaction at the anode was an oxidation or a reduction and to give an explanation for their responses.

This section proved to be quite challenging for many candidates. The major challenges were as follows:

- There was confusion as to whether oxidation or reduction involved loss or gain of electrons.
- Candidates did not associate oxidation with the reaction at the anode.
- The reaction was described as *reduction* but the explanation given was loss of *electrons*.
- Some explanations involved an increase in oxidation state but there was no supporting evidence from the calculation of the oxidation states.

The expected response was *oxidation* at the anode due to loss of *electrons*.

In Part (e), candidates were required to state two changes that would occur in the electrolyte used. Some candidates stated the changes that would take place at the electrodes instead of in the electrolyte. Many candidates were able to state at least one of the changes expected.

The expected responses were:

- The colour of the electrolyte faded.
- The electrolyte became more acidic.
- Copper particles were dislodged from the electrode and were deposited in the electrolyte.

Part (f) required candidates to calculate the mass of the copper that would be deposited at the cathode with the passage of 5 amperes of current through the electrolyte for half an hour. Many candidates were able to earn at least one of the four UK marks awarded; however, several candidates failed to use

- the correct half equations for the reaction at the cathode
- an ionic half equation
- seconds when calculating quantity of electricity
- the mole ratio to relate the number of moles of electrons to the number of moles of copper produced.

The expected response was

Ionic equation	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
Quantity of electricity	$5 \times (30 \times 60) = 9000$ C
No. of Faradays	9000 C / 96500 C = 0.093 F
No. moles copper formed	0.093 / 2 = 0.047 moles
Mass copper formed	$0.047 \times 64 = 2.98$ g

Part (g) required candidates to state how the apparatus depicted in Figure 3 should be modified at the anode, cathode and electrolyte, so as to obtain pure copper from impure copper.

Although many candidates were able to earn at least one of the three marks, too many candidates failed to earn maximum marks here. Some did not distinguish between pure copper and impure copper and stated that 'copper' would be at the anode and cathode.

The expected response was

At anode: impure copper
At cathode: pure copper
Electrolyte: no modification required

Question 3

Syllabus Reference: B1:

This question tested candidates' knowledge of chemistry of alkanes and alkenes, and the reaction of alcohols and acids to produce esters.

Part (a) (i) was very well done and most candidates correctly identified A as belonging to the alkenes and B to the *alkanes*. The more common errors were:

- Incorrect spelling of alkane and alkene
- Stating the specific names of the compounds (propene and butane) instead of stating the names of the homologous series
- Mixing up the series names and classifying A as alkane and B as alkene

In Part (a) (ii), candidates were required to give the general formulae for alkanes and alkenes. Surprisingly, this proved to be difficult for many candidates. The common errors were:

The variable n was represented as indices such as C^nH^{2n} instead of C_nH_{2n}
Incorrect inclusion of plus signs in the general formulae such as $C_n + H_{2n}$ and $C_n + H_{2n+2}$
Stating the chemical formula instead of the general formula

For Part (a) (iii), candidates were required to state one condition for the chlorination of B and to draw fully displayed structures for the products of the chlorination of A and B.

Most candidates correctly identified light as the necessary condition of the chlorination of the alkane. Common incorrect responses were heat, temperature, pressure, darkness, dim light and catalyst.

For Part (iii) b), common incorrect responses included:

- An increase in the carbon skeleton
- Chlorine instead of a carbon skeleton
- Products having branched carbon skeletons
- Products containing double bonds
- Bromine instead of chlorine being the atom added or substituted
- Chlorine atoms added to Carbons 1 and 3 instead of Carbons 1 and 2 for the reaction of A

For Part (b), the correct response for the role of potassium was *oxidizing agent*. However, many candidates incorrectly indicated that the dichromate was acting as a catalyst in the reaction.

In response to providing a chemical equation for Part (b) (ii), the following incorrect responses were noted:

- Candidates had problems writing the correct formula for ethanoic acid, magnesium oxide (represented as MgO_2) and magnesium ethanoate.
- In a few instances, hydrogen and oxygen were included as products in the reaction instead of water.
- Equations were unbalanced.
- Potassium dichromate was included as a reactant.
- Hydrogen represented as h instead of H.

The expected equation was

$$2CH_3COOH + MgO \rightarrow (CH_3COO)_2Mg + H_2O$$

The gas formed when Compound E (carboxylic acid) reacts with calcium carbonate is carbon dioxide. In Part (b) (iii), candidates were required to give a test for carbon dioxide and were expected to give the limewater test. This test gives a white precipitate when carbon dioxide is bubbled through calcium hydroxide solution (limewater).

Common Incorrect Responses

- The wrong tests were given. These included tests for hydrogen gas, with litmus paper, and breathalyzer tests.
- Lime water was incorrectly identified as lime soda, soda lime, lime juice, calcium carbonate and sodium hydroxide.
- Physical tests were used instead of chemical tests.

In Part (b) (iv), candidates were required to name the homologous series to which J belongs. The correct homologous series is Esters. A significant number of candidates identified the series as 'organic acids', 'carboxylic acids'. Less common responses included 'ester linkage', 'polyester', 'esterfication', 'amides' and 'amines'.

<u>Question 4</u>

Syllabus References: A: 2.7, 2.8, 4.1, 4.2, 4.5, 6.1, 6.3

Candidates were tested on the uses of radioisotopes, the arrangement of elements in the periodic table, ionic bonding and predicting properties of unknown elements based on their electronic configuration. Candidates were provided with four unknown elements, P, Q, R and S, and their electronic configurations:

P: 2, 7 Q: 2, 8, 2 R: 2, 8, 6 S: 2, 8, 8, 2

In Part (a), candidates were required to state two other uses of radioisotopes (apart from Uranium-235 which is used for energy generation) and explain the importance of each.

It appeared that some candidates failed to read the question since they wrote the importance of energy generation, which was already given in the question. Additionally, many candidates were unable to explain the importance of either one or both of their chosen uses. However, many candidates had information on a number of current uses of radioisotopes.

The expected response included

- Carbon-14 dating — a method of finding out the age of once-living, archaeological specimens that are no more than 50 000 years old.

- Tracers — substances containing very small quantities of radioisotopes to allow for easy detection and measurements often used to study chemical changes within living organisms.
- Radiotherapy — used to treat cancer cells because it destroys cancer cells more rapidly than normal cells.
- Pacemakers — some artificial pacemakers are powered by the energy produced by radioactive decay.

In Part (b) (i), candidates were required to outline the criteria for placing elements in the Periodic Table, and state the appropriate group and period for each of the unidentified elements, P, Q, R and S.

Many candidates wrote much more than what was required, and included in their answers criteria based on atomic number, metallic and non-metallic properties, etc. The majority of candidates were able to list the correct group and period for the four unknown elements.

The number of *valence electrons* (that is, electrons in the outer shell) determines the group number, and the number of *shells* determines the *period* number. Hence the correct placements were:

Element	Group	Period
P	7	2
Q	2	3
R	6	3
S	2	4

In Part (b) (ii), candidates were required to deduce whether the compound formed between P and Q was ion or covalent, use *dot-cross* diagrams to show the bonding in the compound, and write its formula.

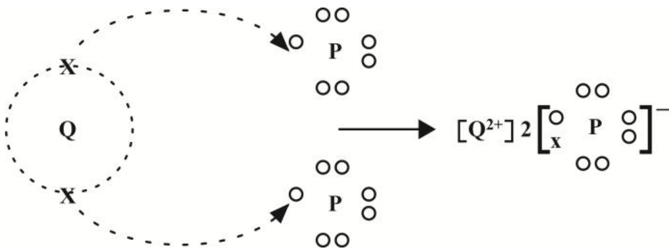
Many candidates correctly deducted that the bonding was ionic. [This is strictly true for the metals in Groups 1 and 2 combining with the non-metals in Groups 6 (16) and 7 (17)]. Many candidates showed the transfer of both valence electrons from one atom of Q to two atoms of P, that is, one electron to each P atom. However, some candidates did not show the electron configuration or the charge of the ions that were formed after the transfer of electrons. Many candidates correctly indicated that the formula for the compound formed between Q and P was QP_2.

Common Incorrect Responses

- Incorrectly showing Q and P sharing electrons in covalent bonding
- Showing both electrons of Q being transferred from one atom of P
- Giving the incorrect charge on the cation of Q as Q^+ instead of Q^{2+}

Candidates were expected to state that the bonding between Q and P is ionic.

The ionic bonding diagram should show both valence electrons from Q being transferred to the valence shells on two atoms of P, resulting in a Q^{2+} cation and two P^- anions.



The compound formed between Q and P must be neutral and so two P^- anions are required to balance out the 2+ charge on Q^{2+}, i.e (+2) + (2 x $^-$1) = (+2) + ($^-$2) = 0. The correct formula is therefore QP_2.

In Part (b) (iii), candidates were asked to compare the reactivity of elements Q and S with dilute hydrochloric acid, and write a balanced equation for one of the reactions.

A number of candidates identified element Q as magnesium and element S as calcium and then made use of the reactivity series to state that calcium was more reactive to magnesium, rather than comparing the reactivity based on trends in Group 2. Many candidates correctly stated that reactivity increased down the group, and so element S would be more reactive. However, some did not state which of the elements was lower in the group.

Common Incorrect Responses

- Q is more reactive than S.
- $Q + 2HCl \rightarrow QCl + H_2$.
- A number of candidates had water as a product of the reaction.

Candidates were expected to state that Q and S are in the same group and that element S is lower down in the group and is therefore more electropositive and more reactive; hence, element S would react more vigorously with dilute hydrochloric acid.

The correct equation (using either Q or S) is:

$Q(s) + 2HCl(aq) \rightarrow QCl_2(aq) + H_2(g)$

<u>Question 5</u>

Syllabus References: B2: 1.1, 4.1, 6.1, 8.1; A: 6.8

This question tested candidates' knowledge of corrosion of metals, with specific reference to aluminium and iron.

In Part (a), candidates were required to state the property of metals that is responsible for corrosion and describe the process of corrosion.

Many candidates correctly stated that oxygen (from the air) and water (moisture, rain) were necessary for corrosion to take place, but could not identify the property of the metal that is responsible for corrosion.

Expected Responses

Metals corrode because they are reducing agents, and they react readily with other elements such as oxygen and sulfur in the presence of moisture to form oxides and sulfides, respectively. (Note: since metals are reducing agents, they will react with oxidizing agents). Two common oxidizing agents are oxygen (from the atmosphere) and sulfur (from natural deposits).

For Part (b), candidates were required to write three relevant chemical equations for the corrosion of iron.

Candidates' Performance

The majority of candidates were unable to write three correct equations.

Common Incorrect Responses

- $Fe + H_2O \rightarrow FeO$
- $Fe + O_2 \rightarrow FeO$
- $Fe(s) + O_2 \rightarrow Fe_2O_3$
- $Fe^{2+} + O_2 \rightarrow FeO$

The equations were expected to show the oxidation of elemental iron (oxidation state = 0) to the +2 state in iron(II) hydroxide ($Fe(OH)_2$), and then further oxidation to the +3 state in hydrated iron(III) oxide ($Fe_2O_3xH_2O$).

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

$$Fe^{2+}(aq) + 2OH^-(aq) \longrightarrow Fe(OH)_2(s)$$

$$Fe(OH)_2(s) \xrightarrow{O_2} Fe_2O_3xH_2O$$

In Part (c), candidates were required to explain why the corrosion of aluminium is beneficial while the corrosion of iron is not. Many candidates stated that the corrosion of aluminium is beneficial since it formed a protective layer, but did not indicate what the protective layer was.

Many candidates referred to aluminium oxide as rust. They discussed corrosion in general but did not discuss the specific cases of iron and aluminium, which were required.

The expected responses were:

Aluminium — Aluminium reacts with oxygen from the air to form aluminium oxide (Al_2O_3). This aluminium oxide layer sticks to the surface of the metal, and is impervious to water. This prevents water from attacking the metal below the oxide surface layer. Hence, corrosion of aluminium protects it from further corrosion, and makes it very stable.

Iron — Corrosion of iron leads to the formation of a *flaky* layer of rust. Once this flaky layer of rust forms, it does not adhere to the metal surface but it easily falls off and exposes fresh surfaces of the iron for further rusting. This corrosion of iron causes a continuous eroding of the metal surface, which leads to weakening of the metal, and could cause structural damage.

For Part (d), candidates were required to explain why it is not advisable to prepare acidic foods in aluminium pots.

The majority of candidates indicated that the acid in the foods would react with the aluminium metal, but many did not realize that the acid would have to first react with the oxide layer in order to expose the metal. The majority of candidates indicated that the product(s) of the reaction would be harmful or poisonous.

Common Incorrect Responses

Aluminium would react vigorously with the acid in the food.
Aluminium would react with the acid producing hydrogen, which would then explode and cause harm.

Candidates were expected to state that the acid in the food will react with the aluminium oxide layer:

$6H^+(aq) + Al_2O_3(s) \rightarrow 2Al^{3+}(aq) + 3H_2O(\ell)$

to form aluminium salt(s) and water. The removal of the protective oxide layer exposes the reactive aluminium metal which will continuously react with the acid in the food, and cause degradation/corrosion of the aluminium metal. This causes aluminium ions to enter the food and eventually the body. Aluminium ions have been linked to diseases such as Alzheimer's.

<u>Question 6</u>

Syllabus References: C2: 3.8, 3.9, 3.10, 3.12

This question tested candidates' knowledge of the properties of water and how they relate to the functions of water in maintaining life. The average mark on the question was 6.6 out of 15 or 44 per cent. Thirty-five per cent of candidates were able to score 8 or more of the 15 marks.

Candidates performed poorly on this Part (a). Many of them were unable to correctly identify the properties of water but some could state functions that are related to maintaining life. A misconception of many candidates is that oxygen in the water molecule is the oxygen that is available to aquatic organisms.

Common Incorrect Responses

- Water is necessary for drinking.
- Water is necessary to bathe, cook and clean.
- Water evaporates, condenses as clouds and falls as rain in the hydrological cycle which is important to life.
- Rainfall cools the earth.
- Water is made up of hydrogen and oxygen, and the oxygen is used in respiration in living things.
- Water is clear/transparent.

The expected responses were:

Water is a solvent which dissolves substances essential for metabolic processes in living things.
The high specific heat capacity of water helps living things to maintain a constant body temperature when ambient temperatures rise.

Water is not very volatile (has a high heat of vaporization) so that evaporation causes cooling of the living thing.

Water's density decreases on freezing so that bodies of water freeze at the top allowing life to continue underneath the ice.

The following points were also credited:

- Water keeps the body hydrated/prevents dehydration.
- Water provides a habitat for aquatic organisms.

Part (b)(i), tested candidates' ability to define the term *hard water*. Candidates performed poorly on this part of the question. A very large number of them defined *hard water* as ice.

Common Incorrect Responses

- Hard water contains dissolved impurities/minerals/ions.
- Hard water contains dissolved calcium and/or magnesium.

The expected responses were:

- Hard water is water which contains dissolved calcium and/or magnesium salts/ions.
- Hard water is water which contains Ca^{2+} or Mg^{2+} ions.
- Hard water is water which lathers with difficulty.

Part (b)(ii) tested candidates' knowledge of methods used to soften hard water and their ability to write an equation to represent the process.

Candidates who defined hard water as 'ice' and then stated that 'hard water is softened by heating' were not credited. Many candidates could not write a balanced equation for the softening of water by heating or adding sodium carbonate.

Common Incorrect Responses

- Water is softened by chlorine/bleach.
- Water is softened by adding lime/calcium carbonate.
- Water can be softened by adding acid:
  $CaCO_3(S) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(\ell) + CO_2(g)$
- Water is softened in the purification process: passed through a sand filter, put in a settling chamber.

The expected responses were:

- Hard water can be softened by heating/boiling.
  $Ca(HCO_3)_2(aq) \rightarrow CaCO(s) + CO_2(g)$

- Hard water can be softened by adding sodium carbonate/washing soda.
  $CaSO_4(aq) + Na_2CO_3(s) \rightarrow CaCO_3(s) + Na_2SO_4(aq)$

- Hard water can be softened by using ion exchange resin.
  $Ca^{2+}(aq) + 2Na--X(s) \rightarrow Ca--X(s) + 2Na^{+}(aq)$

Part (c) tested candidates' knowledge of methods that individuals and communities can use to manage and maintain the environment. Most candidates were able to correctly state methods which could be used to manage and maintain the environment.

Common Incorrect Responses

- Pass laws to prohibit...
- Build water treatment plants

The expected responses were:

- Conserve resources by
  - reducing the amount of solid waste produced
  - reusing articles such as glass bottles and plastic containers
  - recycling substances such as aluminium, iron, glass and paper

- Conserve water by

  – turning off the tap/shower when not using
  – fixing leaks
  – using a cup of water to brush teeth
  – using a bucket to wash the car
  – using wash water to water plants

- Conserve energy by

  – turning off lights when not in the room.
  – reducing energy consumption by carpooling/walking instead of using a car to go to a nearby destination.
  – using alternative sources of energy, for example, solar power.

- Properly dispose of garbage in sealed bags/covered bins/sanitary landfills/do not litter.

Also credited were:

- Organize clean-up days/keep waterways clear of garbage.
- Plant trees.
- Do not burn garbage.

Paper 032 – Alternative to School-Based Assessment (SBA)

Syllabus References: A: 1.1, 1.2, 5.2, 5.3

<u>Question 1</u>

This question tested candidates' knowledge of states of matter, in particular, the cooling curve as well as separation of mixtures by filtration and calculation of percentage composition by mass. The maximum marks available were 26 and the majority of candidates gained 15 or more.

Part (a) required candidates to

(i) read and record temperature readings from the thermometers given

(ii) plot the temperature readings against time on the axes provided and draw a smooth curve through the points

(iii) interpolate from the graph the temperature at a given time

(iv) deduce the physical state of the substance at a given time

(v) compare the arrangement of particles at two different stages of cooling.

Most candidates read all the thermometers correctly although a few of them were challenged in cases where the thermometer readings were not whole numbers. The graph was generally well done but some candidates had difficulty using the scale provided and some used rulers to join the points rather than drawing a smooth curve. Many candidates could not interpolate the temperature readings of the graph at a given time but this may have been due to their inability to utilize the scale effectively.
It appears that the concept of the melting point was not fully understood in that some candidates did not recognize that the constant temperature was indeed the melting point.

Candidates were asked to indicate the physical state of the substance while in the plateau region of the curve. Very few recognized that it would be a mixture of both solid and liquid, most candidates said one or the other and a few used terms such as ‘semi-solid’.

Determining and comparing the arrangement of the particles at two different time intervals of cooling proved difficult and most responses were very vague. It was evident that not many candidates were able to identify that the substance was transitioning from liquid to solid. Some candidates incorrectly described arrangements which suggest that the substance was transitioning from a solid to a liquid and in a few cases, the arrangement for gases was described.

In Part (b), candidates were presented with a known mass of a mixture of sand and copper(II) sulfate to which they would add water, filter and evaporate the filtrate to dryness. At the end of the experiment they were required to identify what they would observe in the beaker and on the filter paper; read the balances and determine the mass of the residue and the resulting mass from evaporation; calculate the percentage of mass of each component of the mixture and give a reason why the sum of the percentage masses was different from 100 per cent.

When asked to describe what can be observed in the beaker at the end of the experiment, some candidates described the contents of the beaker at the beginning of the experiment. A typical answer would have been *a blue solution of copper sulfate with sand at the bottom* rather than just a blue solution. However, the majority of the candidates did recognize that sand would be in the filter paper.

Again, the reading of the scale on the balance presented some difficulty. Each interval on the scale represented 0.2 grams. The correct answer would have been *6.3 grams* but instead, responses like 6.15 and 6.25 grams were given for the mass of the residue. In addition, a large number of candidates did not recognize that they were required to subtract the mass of the watch glass in order to calculate the mass of the residue. Similar mistakes were made when asked to calculate the mass of solid.

In calculating the percentage mass of the sand and copper(II) sulfate in the mixture, the most common error seen was that candidates did not use the original mass of the mixture that was given before the experiment started. Several candidates incorrectly used the sum of the mass of the residue and solid calculated. Very few of them were able to suggest why the percentage masses of the two components determined from the experiment did not add to 100 per cent. Rather than suggest that some of the copper sulfate may have been lost in the sand or some of the solid was lost during transfer, some candidates suggested that the mass of the watch glass was subtracted.

<u>Question 2</u>

Syllabus References: B2: 7.1, 7.2, 7.3.

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, R, as well as its aqueous solution. Overall, this question was poorly done with more than 50 per cent of the candidates scoring three or fewer of the ten marks.

The majority of candidates seemed not to be familiar with qualitative analysis — the tests as well as making observations. For example, when given that the addition of sodium hydroxide dropwise, then in excess, implied that Zn^{2+}, Al^{3+} or Pb^{2+} ions were present, some candidates simply stated that a precipitate was formed without indicating that it was soluble in excess, identifying the colour, or stating that a white solution was formed. In addition, when told that the addition of dilute nitric acid to the residue followed by testing the gas with filter paper dipped in acidified potassium dichromate led to the deduction that sulfur dioxide gas was given off, it was apparent that some candidates did not know that they were expected to observe when a gas was given off. The correct response would have been a *pungent or choking smell* or an *irritating odour*, however, effervescence was accepted.

Question 3

Syllabus References: A 5.1, 5.4

This question tested candidates' planning and designing skill. Candidates were asked to plan and design an experiment which could be used to determine whether water-soluble, black ink from two different manufacturers consist of the same components. They were required to suggest a hypothesis, procedure, apparatus and materials, data to be collected, variables to control, as well as to discuss the results as it related to the hypothesis. Candidates performed unsatisfactorily with the majority earning six or fewer of the 12 marks.

The language of a hypothesis is important. Most candidates wrote aims or questions for hypotheses. It was expected that some of the candidates would recognize that the procedure should be based on chromatography. Some candidates did but other popular methods were based on dissolving the inks, titration and distillation. However, candidates who suggested chromatography as the method of choice had difficulty describing the process. Some suggested placing the ink in the beaker but the common mistake was allowing the dot of ink to be immersed in the solvent. Although it was expected that candidates would use either filter paper or chromatography paper, many different types of paper were suggested, such as litmus, cobalt, carbon, calligraphy and tissue paper. In the procedure, candidates earned marks for placing the spot on the paper above the solvent level, allowing time for separation and for being able to make a comparison between the two inks. Some candidates also had difficulty determining the apparatus they would need to carry out their procedure.

For the data to be collected, marks were awarded for the number of spots, the colour of the spots and the distance they travelled. Most candidates stated two of the three points; the one most commonly neglected was the number of spots. Regardless of the procedure given, the amount of ink used was the most popular answer for the variable to control.

For the discussion, again, only the colours and distance travelled were mentioned and the number of spots was omitted. Also, candidates were expected to use diagrams to illustrate their discussion but in many cases the diagrams did not complement the discussion but were used independently.

Paper 031 – School Based Assessment (SBA)

Planning and Designing (PD) Skill

Generally, the standard of the laboratory exercises assessed for the Planning and Designing (PD) skill has declined this year as there was a 10 per cent increase in exercises with unsatisfactory PD skills. This was due mainly to the noticeable increase in the number of standard practical exercises presented this year. Standard practical exercises are those which can be obtained from a chemistry text, and are therefore deemed inappropriate for PD activities, for example:

Plan and design an experiment to determine

- the effect of concentration on the rate of a reaction
- the products of electrolysis of H_2SO_4 using inert electrodes
- the conditions for rusting.

Various formats have been used for the presentation of PD skills, some of which make it very difficult to moderate. Below is a suggested format which may be useful to both teachers and students:

- Scenarios

  – Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise. These should also be included in the teachers' mark scheme.

  – It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PD's) be found.

  – It is not recommended that students be left to generate the problems/scenarios of their own; however, in circumstances where this is done these problems/scenarios should be vetted by the teacher to make sure that they are testable and chemistry based.

- Hypothesis

  – The hypothesis should be testable.

  – As much as possible the manipulated variable should be included in the hypothesis.

  – The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used on the experiment should be outlined in the hypothesis.

  – The language of the hypothesis is also important. It should be stated like an aim.

- Aim

  – Students should be encouraged to specify the method or technique to be employed in the experiment.

  – The aim must relate to the hypothesis as well as the problem statement.

- Apparatus/Materials

  – Traditionally, most teachers require that the apparatus and materials be placed before the procedure in keeping with the format used for the laboratory exercises. Please note that PD skills in this section may also be written and accepted after the procedure as it is a good practice to identify from the procedure the list of apparatus and materials required. This is better done while planning the experiment rather than writing a procedure to fit the apparatus and materials.

  – Students should also be encouraged to pay special attention to this section since a mark is deducted for every piece of essential apparatus omitted as determined by the suggested procedure.

- Procedure

  – Special attention must be given to the tense used in the procedure. Students should be taught to write the procedure in the present or future tense; any other tense is unacceptable.

  – As mentioned before, this section may also be placed before the apparatus and materials section.

- Variables

  – It is recommended that the variables; manipulated, control and responding, be placed immediately after the procedure. Students should be encouraged to list these variables separately as this is an exercise in critical analysis.

- Data to be collected

  – Some students refer to this section as 'Expected Results'. It is recommended that the term *Data to be Collected* be used rather than 'Expected Results'.

  – In this section, the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis should be recorded. Please note that actual values should not be recorded in the tables.

  – The data to be collected may be presented in tabular form or as a description of specific data including units, where appropriate.

- Some examples

  – When doing a titration, the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to be used as data collected.

  – If chromatography is used, then the data collected should included the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin. R_f values should never be used as data to be collected since this is also calculated.

- Treatment/Interpretation of Data

  – Again it is recommended that the term *data* be used rather than 'results' in the heading in an attempt to make it clear that this section looks at how the data collected will be used to prove or disprove the hypothesis.

  – This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

Some examples:

- In a scenario where students are trying to find out which brand of vinegar is more concentrated, the Interpretation of Data could be: *If Brand Y vinegar uses the* <u>*least volume*</u> (Data to be collected) *to neutralize X cm^3 of base then Brand Y is the* <u>*most concentrated vinegar*</u> **(stated in aim)**, *and therefore the hypothesis is supported.*

- In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *If both brands of ink* <u>*contain the same number of components with the same colour and are the same distance from the origin*</u> **(Data to be Collected)**, *then* <u>*both brands of ink contain the same dye*</u> **(stated in the aim)** *and therefore the hypothesis is supported.*

- Limitations/Precautions/Assumptions

    – It is recommended that teachers assist students in distinguishing between these terms. While they can be related, the way that they are stated can make a significant difference.

Please note that *Sources of Error* should not be presented in a PD lab since it refers to a lab that has been carried out.

In addition, teachers should also be aware of the following:

- All PD activities should be based on chemical concepts. Although scenarios may involve Biology, Physics, Food & Nutrition, the focus of the activity must involve chemical concepts related to the Chemistry syllabus.

- Students should undertake at least four PD activities over the two-year period. When this is not done, students are at a disadvantage.

- Some PD exercises submitted for SBA were assessed for other skills as well. This suggests that the exercise was carried out and so cannot be moderated for PD skills. This places the students at a serious disadvantage.

- While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does indeed suit all the PD activities submitted. If not, each PD activity should have a separate mark scheme.

To assist in improving the standard of PD exercises, some ideas for possible PD activities adapted from Jacques (2006) are suggested below.

1. Comparison of homemade vinegar against store-bought vinegar.
2. Best solvent to remove ink stain from a shirt.
3. Comparison of the heat content of alcohols (how the number of carbon atoms in the alcohol affect the heat of combustion)
4. Which water source is best for rusting
5. Vitamin C content in different brands of Vitamin C tablets or fruit juices
6. Electroplating a coin: which would deposit greater amount of metal for a given quantity of electricity — univalent or divalent metal ion. Please note that items like leather belts or sandals should not be used here.
7. Acidity in green-skinned fruits compared to ripened fruits
8. Comparison of different brands of baking powder
9. Comparison to determine if different brands of black marker contain the same ink
10. Comparison of a recently discovered fuel with gasoline (existing fuels)
11. Comparison of hardness of water using soap
12. Comparison of melting point of pure and impure substances, for example, pure stearic acid and stearic acid with a small amount of glucose added
13. Eating peanuts from Brand A makes one thirstier than eating peanuts from Brand B

Please find below more detailed information as examples for number 4 and number11.

4. – *Scenario:*

> *Mrs Jones and Mrs Thompson both bought steel burglar bars for their homes. Mrs Jones lives near the beach while Mrs Thompson lives inland. Three years later Mrs Jones's bars have more rust than Mrs Thompson's. Mrs Jones believes that the rust is due to the exposure of the burglar bars to water from the sea. Plan and design an experiment to determine whether sea water accelerates rusting in steel.*

Hypothesis:

Iron rusts faster when exposed to salt water than fresh water.

Aim:

To investigate the effect of salt water as opposed to fresh water on iron by measuring the mass of iron produced.

Variables:

Manipulated – types of water
Controlled – volumes of water used and the time exposed to air
Responding – mass of rust

11. – *Scenario*

Debbie went in Dominica and while washing clothes she realized that she used less soap than when washing in Barbados. Plan and design an experiment to explain this observation.

Possible hypotheses:

1. *The water in Dominica is softer than the water in Barbados*
2. *The water in Barbados contains more calcium and magnesium ions than the water in Dominica.*

Possible Aim:

To determine which water contains more calcium and magnesium by ionic precipitation

Variables:

Manipulated – types of water
Controlled – type of detergent, volume of water
Responding – the mass of precipitate formed

Analysis and Interpretation (AI) Skill

The Analysis and Interpretation skill continues to be one of the better assessed skills. In general, the qualitative analysis and calculations were well done. However, to ensure continued improvement here are some points to note:

- Observations, definitions, background information, plotting of graphs, and questions which are not directly related to the specific practical should not be assessed under AI.
- Emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.
- Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that they understand what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again, *the use of the equation* $M_1V_1=M_2V_2$ *is not accepted*.
- Teachers should emphasize writing correct (conventional) formulae, for example, sodium chloride as NaCl and not NaCL and Mg not mg for magnesium.
- Students should be required to complete their table of contents.
- Teachers are encouraged to provide students with more guidance in 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.

- Create more explicit mark schemes:

    - 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 a school/centre, then teachers should collaborate and submit one common mark scheme.
    - When interpolation from a graph is marked for AI skill, the mark scheme needs to be more explicit to guide the moderation process.