

CARIBBEAN EXAMINATIONS COUNCIL

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

JANUARY 2013

**CHEMISTRY
GENERAL PROFICIENCY EXAMINATION**

GENERAL COMMENTS

Overall, candidates' performance in this sitting of the examination improved compared with performance in 2012.

This report provides feedback on the strengths and weaknesses reflected in candidate performance indicates the expected responses, and notes the common errors made by candidates. As such, it should be of value to both students and teachers for self-assessment and planning. It is anticipated that if these comments are noted and the recommendations integrated into teaching and learning on a wide scale, then this should lead to an improvement in overall performance on the examination.

Candidates demonstrated general knowledge of some of the specific and important concepts relating to the following areas:

- Reading scales from diagrams of instruments
- Calculating number of moles given mass
- Calculating gas volumes at RTP
- Calculations that involve equations with 1:1 mole ratio
- Drawing bonding diagrams for ionic compounds
- Calculation of the quantity of electricity that passes through an electrolytic cell given current and time
- Drawing structural formulae and naming alkanes and alkenes
- Writing some equations, for example, combustion of hydrocarbons and reaction of metals and acids except for organic acids
- Uses of polymers
- Understanding of the carbon cycle
- Principles underlying reactivity series of metals
- Physical properties of metals
- Strategies that can be used for preserving the environment

Candidates seemed to have challenges in the following areas:

- Redox reactions
 - differentiating between oxidizing and reducing agents
 - interpreting
- Recalling specific details, such as, conditions and reactants for several chemical reactions outlined in the syllabus, definitions of concepts
- Differentiating between the principles of metallic and ionic bonding
- Qualitative analysis for the identification of cations and anions
- Polymers

Poor performance was noted in:

- Writing and balancing equations and use of the correct mole ratio
 - Incorrect formulae which resulted from incorrect valencies were used throughout. Consequently, formulae were incorrectly written in equations and marks were lost.
 - Writing ionic equations to show reactions at the electrode - the weaknesses here relate to the wrong formulae for ions and the adding and subtracting of electrons to show the discharge of ions.
 - Incorrect formulae were used for salts of organic acids.
- Definitions of key concepts – Evidently, conceptual understanding was lacking.
 - This was most noticeable in the definitions for *rate of reaction* and *polymer*.

- Weak explanations for various phenomena
 - Candidates provided poor explanations for some of the claims they made. For example, in Question 1 of Paper 02, many candidates were able to compare the volumes of gases obtained for Experiments 2, 3 and 4. However, they were not able to explain the reasons for these differences.
 - Many of the types of errors mentioned in previous reports were evident in the responses. Candidates have a general idea of some topics but lack the specific knowledge to show depth of understanding. For example, there was the tendency to attribute conduction of electricity to the movement of electrons regardless of whether this was in reference to a metal or an electrolyte. There were many instances of descriptions of circuits that had the ammeter, instead of the electrodes, submerged in the electrolyte. It seems that 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 chemical terms during classroom conversation should be the norm. In addition, it is important that students be provided with visual images of concepts such as general formulae, dot-cross diagrams and arrangements of apparatus for experimental procedures. Finally, strong emphasis should be placed on students writing clear and accurate accounts of phenomena using chemical terms correctly. Teacher feedback to students should help them to understand the gaps between what they have written or said and the required standard.
- Limited understanding of practical procedures
 - It appeared that candidates were unfamiliar with testing for strong and weak electrolytes.
 - They also lacked knowledge of the solubility of salts.

DETAILED COMMENTS

UNIT 1

Paper 01 – Multiple Choice

This paper assessed Sections A and B of the syllabus. Performance on this paper declined slightly compared with the performance in 2012 and 2011. The mean score earned by candidates was 50 per cent, with a standard deviation of 10.

Paper 02 – Structured/Extended Response Questions

Question 1

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

Parts (a) to (e) tested knowledge of factors that affect the rate of a chemical reaction; use of oxidation numbers to explain oxidizing agents and relative reactivity of zinc and magnesium with dilute acid. Candidates were required to calculate the volume of gas produced at RTP when a given mass of zinc reacted with dilute hydrochloric acid.

Performance of Candidates

In Parts (a) and (b), most candidates gave incorrect or incomplete definitions of the *rate of reaction*. Generally, they failed to include key components such as the *change in concentration of the reactants or products with time*. Most candidates gave responses such as – ‘how long the reaction would take to

occur' or 'the time taken for the reaction to take place'. Many repeated the term 'rate' in their response. Most candidates scored all three marks for completing Table 1 using the data in Figure 1.

A correct response for Part (a) was *the change in concentration of product or reactant per unit time*. The correct readings from Part (b) were 171 cm³, 187 cm³ and 46 cm³.

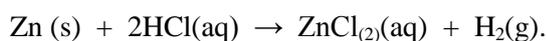
In Parts (c) (i) to (iii), candidates were required to write a balanced equation for the reaction between zinc and dilute hydrochloric acid, deduce the oxidizing agent for the reaction based on oxidation number and determine the volume of gas produced at RTP from reacting 1 g of zinc with excess dilute acid.

Candidates performed fairly well on the writing of the equation and calculation of the volume of hydrogen gas produced. However, many of them lost marks because they were unable to deduce the oxidizing agent and they confused *oxidizing agents* and *reducing agents*. Many candidates were not sure how a change in oxidation number during a reaction could be used to determine the oxidizing agent and so gave incorrect responses.

Some common **incorrect** responses noted were:

- Formula of zinc chloride as ZnCl instead of ZnCl₂.
- Zinc is the oxidizing agent.
- Hydrogen is the oxidizing agent.

The expected equation for Part (c) (i) was



The oxidizing agent was HCl or H⁺ as the oxidation number changed from +1 (in H⁺) to 0 (in H₂). This decrease in oxidation number indicates that the H⁺ was reduced and hence was the oxidizing agent.

One correct approach to calculating the volume of hydrogen is as follows:

$$\begin{aligned} \text{No. of moles Zn} &= 1/65 \\ \text{Mole ratio Zn:H}_2 &= 1:1 \\ \text{No. of moles H}_2 &= 1/65 \\ \text{Volume H}_2 &= \text{No. of moles} \times \text{Volume of 1 mole} \\ &= 1/65 \times 24 \\ &= 0.37 \text{ dm}^3 \end{aligned}$$

In Part (d), candidates were required to compare the volume of gas obtained for Experiments 2, 3 and 4 with that obtained in Experiment 1 and provide explanations for the differences. Candidates performed well on comparing the volumes of gas. However, for the most part, they did not provide satisfactory explanations for the differences in volume. Vague responses which failed to get to the reason for the changes were given - these were not discussed in terms of the reactions at the molecular level. There was also the tendency to repeat the information provided in Table 1 as the explanation for Experiment 1, for example, 'because the powder was used instead of granules'.

Some common errors and **incorrect** responses noted were:

- 'The volume for Experiment 2 was greater because the concentration was greater causing a faster reaction.' This response was considered to be inadequate as it did not address why increasing the concentration resulted in a higher volume of gas.

- ‘The volume of gas for Experiment 3 was greater than Experiment 1 as they used powdered zinc instead of granules which meant that the volume was higher’. This is repetition of the information in Table 1.

The expected responses were:

- *The volume of gas in Experiment 2 was greater than that in Experiment 1 because there are more reactant species in a higher concentration of HCl.*
- *The volume of gas in Experiment 3 was greater than that in Experiment 1 because zinc powder has a greater surface area than zinc granules.*
- *The volume of gas in Experiment 4 was less than that in Experiment 1 since at a lower temperature, collisions are less frequent and less energetic.*

In Part (e), most candidates correctly deduced that using magnesium granules would result in a faster rate of reaction than zinc granules. However, many sketched the graph representing the rate of reaction with magnesium on separate axes to that in Figure 2, contrary to the instructions provided. This made it difficult to compare the steepness of the slopes of the two graphs and hence determine whether candidates understood this concept. Many candidates lost this mark. Candidates are advised to read each question carefully.

Part (f) tested the planning and design skill. Candidates were required to plan and design an experiment to differentiate between a *strong electrolyte* and a *weak electrolyte*.

Candidates performed poorly in this section with the majority earning three or less of the total six marks. Many candidates earned no marks in this section. Candidates seemed to have limited knowledge of electrolysis and limited exposure to laboratory techniques.

The following comments relate to some common errors:

- Many of the circuits described had the ammeter or conductivity metres, instead of the electrodes, dipping into the electrolyte.
- Candidates did not know that barium sulfate was an insoluble salt and was therefore not suitable for use in differentiating a strong from a weak electrolyte.
- Sodium chloride was taken to be a solution and so there was no step included for dissolving it in water. Candidates are reminded that unless otherwise stated, substances that appear in questions should be interpreted as existing in their normal states at room temperature.
- Several **inappropriate** instruments were recorded for measuring the electrolytes required, for example, the burette, pipette and volumetric flasks.
- Many terms were used loosely or confused. These included terms such as electrolyte, electrodes, conductance, strong and weak electrolytes.
- Most candidates earned no marks for Part (ii) as they were not explicit about how the readings could be related to the nature of the electrolyte.

The following comments outline what was expected in response to Part (f):

- *Indication that the materials were prepared for the experiment. Hence, the solid substances used should be put in solution and transferred to beakers for use.*
- *Indication of how the apparatus was set up for conducting the test. There should be evidence that candidates understood that a complete circuit should include an ammeter or conductivity meter included to measure the current. Electrodes should be dipped into the liquids placed in the beaker.*
- *It should be evident that readings would be recorded to supply data for solving the problem.*

- *There should be scope for comparing the conductance of substances in order to differentiate the strong and weak electrolytes.*

Part (f) (ii) required candidates to link the expected observations to the possible deductions. Hence, if the readings on the ammeter or conductivity meter were high then this would signify a strong electrolyte. If the conductance or ammeter readings were low, this would suggest a weak electrolyte.

Question 2

Syllabus References: A1.2, 4.1, 4.2, 4.3, 4.8, 5.4

The question tested candidates' knowledge of the separation of mixtures of solids, based on the strengths of the different inter-particle forces.

In Part (a) (i), candidates were asked to state the name of the process used to separate a mixture of solid sodium chloride and iodine based on the diagram of an experimental set-up of the process that was provided.

Performance of Candidates

For Part (a)(i), most candidates correctly identified the process as *sublimation*.

Some common **incorrect** responses were *evaporation and crystallization*.

In Part (a) (ii), candidates were required to describe the observations that would be made when the mixture of sodium chloride and iodine was heated. Very few candidates provided the correct observations. Some candidates incorrectly stated that the water would evaporate leaving the NaCl and I₂ crystals.

The expected response is given below:

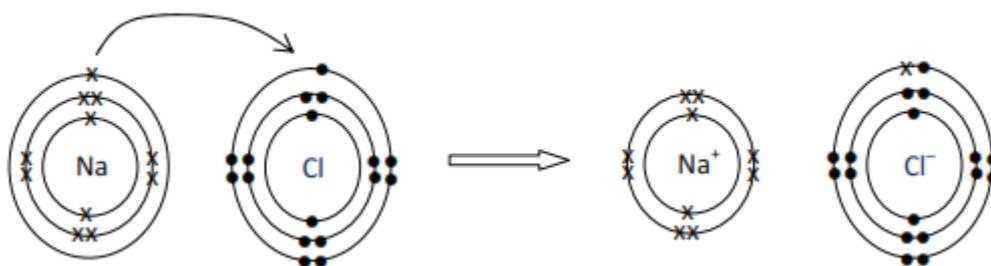
The dark crystals of iodine would have sublimed. Eventually, all the iodine would leave the mixture and be collected on the base of the top beaker, leaving the sodium chloride in the bottom beaker. The observations would be:

1. *Purple gas generated from the bottom beaker.*
2. *Dark-purple solid formed on the outside of the top beaker.*
3. *White solid remained in the bottom beaker.*

Candidates should have a clear understanding of the meaning of *observations* which include colour changes and change of state or phase.

In Part (a) (iii), candidates were required to show the bonding in NaCl using dot-cross diagrams. Candidates performed well on this part. The majority of them correctly indicated the transfer of the single valence electron from the sodium atom to the valence shell of chlorine. Some candidates lost marks for not showing the charge on the ions. A few candidates showed bonding of a covalent type, and so were not awarded any marks.

The following diagram was expected:



This diagram shows the transfer of the single valence electron from the sodium atom, to the valence shell of the chlorine atom. The result is a Na^+ ion and a Cl^- ion. These oppositely charged ions then experience a strong attraction for each other. This attraction is known as *ionic bonding*.

In Part (a) (iv), candidates were asked to explain why gentle heating is suitable for separating I_2 from a mixture of I_2 and NaCl .

The majority of candidates realized that NaCl is an ionic compound and has strong interparticle forces. However, many candidates incorrectly assumed that there was a bond between NaCl and I_2 , and that this bond was being broken under gentle heating.

Many candidates incorrectly focused their responses on the interaction between NaCl and I_2 , rather than the weak intermolecular forces between the I_2 molecules. Candidates were expected to state that *NaCl has strong forces of attraction between its particles, that is, the Na^+ and Cl^- ions are linked by ionic bonds. This makes NaCl stable to gentle heating OR gentle heating will not break these strong ionic bonds. Iodine is a molecular solid with weak intermolecular forces, and gentle heating is sufficient to break these weak forces, separating the I_2 molecules in the solid.*

In Part (b), candidates were required to state whether the same technique could be used for separating a mixture of iron filings and sodium chloride, and then explain their answer with reference to the bonding in Fe. Many candidates did not make reference to the bonding in iron. Some went on to describe a different method of separation, and were not credited any marks.

Some common **incorrect** responses noted were:

- Using a magnet to remove the iron
- Dissolving the NaCl in water and filtering off the iron

The response expected was that *iron has metallic bonding and strong electrostatic attraction. These result in iron having a high melting point. Therefore, gentle heating will not be sufficient to break the bonds either in NaCl or Fe.*

Question 3

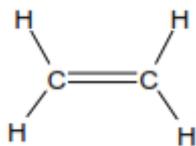
Syllabus References: B1: 2.1, 2.2, 2.3, 2.6, 2.8, 4.3, 4.5

Candidates were tested on their ability to generate names and structures from formulae; to write equations for combustion of a simple hydrocarbon and the reaction of a metal with carboxylic acid; and to predict solubility based on structure and polymerization.

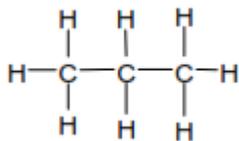
In Part (a) (i), candidates were given the formulae of two hydrocarbons (A, C_2H_4 and B, C_3H_8) and were required to draw the *fully displayed* structures and state the names.

Most candidates were able to deduce the correct structures and names.

The correct structures and names of the two hydrocarbons are:



A (C₂H₄), ethene

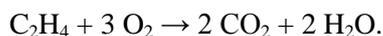


B (C₃H₈), propane

In Parts (a) (ii) and (iii), candidates were required to state whether Compound A burns with a sooty flame or a clean, blue flame, and to write a balanced chemical equation for the reaction.

Approximately half of the candidates stated correctly that Compound A burns with a sooty flame. Since A, ethene, is an alkene, it is expected that the flame would be sooty. Less than 50 per cent of the candidates wrote the correct *balanced* equation for the combustion of ethene.

Too many candidates seemed not to know the basics of writing and balancing chemical equations. The equation for the combustion of ethane is

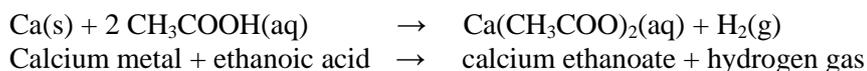


In Part (b), candidates were provided with the fully displayed structures of ethanoic acid (C) and methyl ethanoate (D), and were required to explain why C is soluble in water and D is not. Candidates were asked to write the balanced chemical equation for the reaction of Compound C (ethanoic acid) with calcium metal.

Many candidates identified the OH functional group in the ethanoic acid as being responsible for its solubility but some incorrectly referred to the OH functional group as the 'OH⁻ ion'. The majority of candidates gave an incorrect chemical equation, and seemed very unfamiliar with the topic.

The expected response was that:

Compound C has a polar hydroxyl (OH) group which is attracted to polar water molecules. Hence, Compound C is soluble in water. Compound D is non-polar and would not be attracted to water molecules. Hence, D is insoluble in water. The chemical equation for the reaction of calcium metal with ethanoic acid is:



In Part (c), candidates were asked to define a polymer, state the type of polymerization that occurs when propene (E, C₃H₆) is heated under pressure, the name of the product, and one use of the product.

Although more than 50 per cent of the candidates were unable to correctly define a polymer, more than 60 per cent correctly stated that reaction was *addition polymerization*. The most common **incorrect** response for the type of polymerization was 'condensation polymerization'.

The expected responses were:

A polymer is a long, chain-like molecule formed from many small molecules called monomers.

Propene polymerizes by addition polymerization.

The name of the polymer is polypropene (polypropylene).

Uses include hard plastics for car accessories, toys, domestic wares, shoe heels, crates and carpets.

Question 4

Syllabus references: A. 6.20; 6.23, 6.24, 6.25, 6.27

This question tested candidates' knowledge of electrolysis. Less than 40 per cent of the candidates scored seven or more marks on this question.

Here again, it was clear that candidates confused terms and used them loosely. *Ions* and *electrons* were used interchangeably. There was little evidence that candidates had adequate conceptual understanding of the nature of ionic bonding and what causes ionic compounds to show electrolytic conductivity. Reasons for the conductivity of the different substances were vague.

Most candidates scored the two marks for the diagram. However, many of them found it challenging to write equations for reactions at the electrodes. Calculations were done fairly well and most candidates were able to score at least one mark in this section for calculating the amount of electricity passing through the electrolyte.

Part (a) required candidates to explain the difference in conductivity between magnesium and magnesium iodide. In Part (b), candidates were required to draw a labelled diagram of the apparatus used in the electrolysis of molten magnesium iodide and to write suitable equations to show the reactions at the anode and cathode.

The following comments relate to the main **incorrect** responses:

- Conduction in the electrolyte was attributed to movement of electrons instead of ions.
- Incomplete responses were given for the conduction in Mg. For example, a common response was 'magnesium will conduct electricity because it is a metal and metals conduct electricity'. While this is true, it is not enough to answer the question as it does not show adequate understanding of the activities at the microscopic level. Generally, explanations in chemistry require this level of understanding to be shown.
- Incorrect labelling of the anode and cathode based on the symbol used for the power supply
- Incorrect ionic equations
- Electrons added to the wrong side of the equation, for example, $I^{-}(aq) + 2e^{-} \rightarrow I_2(g)$
 - Incorrect state symbols
 - Writing the equation for the discharge of magnesium ions at the anode instead of at the cathode

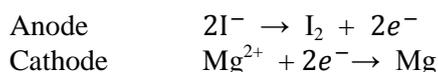
The expected response for Part (a) should show understanding that

- the electrons were responsible for conducting the current in magnesium
- the bonding in magnesium iodide is ionic but the ions are strongly held in the crystal lattice of the solid and therefore unable to conduct the electricity
- in the molten state, the electrons were free to move.

A good response was *magnesium metal conducts electricity due to the presence of mobile electrons in its lattice metal structure (metallic bonding). The electrons are free to move throughout the structure and hence they are able to conduct, that is, carry a charge. Magnesium iodide is an ionic structure and does not possess free electrons. In the molten state due to the presence of mobile ions, magnesium permits conduction.*

For Part (b), it was expected that the diagram should show a complete circuit with the anode labelled as the positive electrode and the cathode the negative electrode.

The reactions at the anode and cathode were as follows:



In Part (c), candidates were required to calculate the mass of product that would be formed when a current of 5 A was passed through the electrolyte for a total of ten minutes.

The main errors were:

- Failure to equate 2F with the deposit of 1 mole of Mg
- Use of incorrect statements – showing indiscriminate use of units and terms
- Calculating the mass of magnesium iodide instead of magnesium

The expected response was as follows:

$$\begin{aligned} \text{Quantity of electricity} &= 5 \times (10 \times 60) = 3000 \text{ C} \\ \text{Number of faradays passed} &= 3000/96500 = 0.031 \\ 2 \text{ faradays deposit} &1 \text{ mole Mg} \\ \text{Moles of Mg deposited} &= 0.031/2 = 0.0155 \text{ moles} \\ \text{Mass of Mg deposited} &= 0.0155 \times 24 = 0.372 \text{ g} \end{aligned}$$

Question 5

Syllabus References: B2: 8.1, 8.2, 8.3, 6.2, 5.2, 1.1, 1.2, 4.1, 4.2

This question tested candidates' knowledge of the carbon cycle and, some reactions of Group II metals and their compounds.

In Part (a) (i), candidates were required to outline how two processes, X (CO_2 in atmosphere \rightarrow Ocean) and Y (CO_2 in atmosphere \rightarrow plants) move carbon through the cycle.

The majority of candidates did not associate process X with the dissolving of CO_2 in ocean water or in rain water. Some candidates wrote that CO_2 moves into the ocean (at process X) but did not state by what process.

The following responses were expected:

- Process X – CO_2 dissolves in water, for example, rain water, and enters the ocean as carbonates.
- Process Y – CO_2 is removed from the atmosphere by photosynthesis in plants.

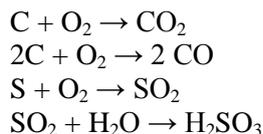
In Part (a) (ii), candidates were asked to describe the process occurring at Z (Fossil fuels \rightarrow CO_2 in atmosphere), explain one harmful effect that could occur as a result of the process and write one supporting, balanced equation.

The majority of candidates correctly identified the process Z as burning/combustion of fossil fuels and gave a relevant equation.

The responses expected were:

Harmful effects due to (i) extensive burning which results in production of large quantities of carbon dioxide, a green-house gas, and contributes to global warming, (ii) formation of carbon monoxide (CO), a toxic gas; in limited supply of oxygen, CO combines with haemoglobin in the body thus reducing oxygen supply, which can lead to death; (iii) burning of leaded fuels releasing toxic lead compounds into the environment which can lead to lead poisoning; (iv) formation of acid rain resulting from the sulfur contained in some fuels. Burning releases sulfur dioxide, SO₂, which forms acid rain which is known to damage buildings, artefacts.

Relevant equations include:



Part (b) was based on information provided in a table.

In Part (b) (i) a), candidates were required to write a suitable equation for the action of heat on the carbonate of R.

Based on the formula of the oxide of R, (RO), it can be deduced that the metal R is in Group II and the formula of its carbonate is RCO₃. A small number of candidates was able to show the correct formula of the carbonate, and fewer could give the equation for its decomposition upon heating. Some candidates incorrectly wrote the formula of the carbonate as R₂CO₃.

The correct equation for the decomposition of the carbonate of R is: RCO₃(s) → RO(s) + CO₂(g).

In Part (b) (i) b), candidates were required to write a suitable equation for the reaction between M and aqueous aluminium ions. Very few candidates gave the correct equation for this reaction. From the formula of the oxide (MO), it can be deduced that the ion of M is divalent, that is, M²⁺. The correct ionic equation is: 3 M(s) + 2 Al³⁺(aq) → 3 M²⁺(aq) + 2 Al(s).

In Parts (b) (ii) and (iii), candidates were required to explain why M is more reactive than R with dilute acid, and to state one physical property and one chemical property that both M and R are likely to share.

Many candidates were able to associate the higher reactivity of M with its higher position in the activity series.

Candidates were expected to state that *M is above aluminium and R is below aluminium in the activity series. Therefore M is higher up than R, and metals higher up in the series are more reactive than those lower down.*

Any appropriate, common physical and chemical properties is acceptable, for example, *physical* – conduct electricity, good conductors of heat; *chemical* – form basic oxides, react with acid to give salt and hydrogen.

Question 6

Syllabus References: C 2.3, C2.3.5, C2.3.6, C2.3.7

In Part (a), candidates were required to identify sources of chlorofluorocarbons and phosphates – two known pollutants and explain how the environment is affected by each.

Candidates performed fairly well on this section and were able to identify sources for the two pollutants. However, the explanations of how they affected the environment tended to be incomplete. In their explanations, they were required to say what each pollutant did to the environment and how the damage was done in each case. In many cases, candidates lost marks for the second part of the response. A common incorrect response was that CFCs lead to global warming.

The expected responses were that

- CFCs are found in aerosols, refrigerants.
Phosphates are found in detergents, fertilizers.
- CFCs produce chlorine radicals which attack the ozone layer and break it down.
Phosphates cause algae blooms in ponds and rivers which use up the oxygen causing eutrophication.

In Part (b), candidates were required to discuss the advantages and disadvantages of using incinerators, landfills and recycling as methods of solid waste disposal.

Many candidates performed well on this item as they were able to find a wide range of advantages and disadvantages for each method. However, the level of discussion was weak and candidates tended to list points without showing how the points related to each other. Candidates' writing skills and ability to express themselves with clarity and precision were the main factors that reduced the overall quality of the responses.

Some of the advantages for using the three methods are as follows:

Landfill	Recycling	Incinerator
<ul style="list-style-type: none"> • Relatively cheap • Large quantities of waste can be disposed of • Can be used for methane production 	<ul style="list-style-type: none"> • Allows for conservation of natural resources • Tends to be energy efficient • Uses less space than landfills 	<ul style="list-style-type: none"> • Reduces the volume of solid waste • Heat produced can be used to produce electricity • Destroys pathogens

Some of the disadvantages for using the three methods are as follows:

Landfill	Recycling	Incinerator
<ul style="list-style-type: none"> • Tend to use up too much land • High start-up cost for equipment and excavation • If improperly used can lead to water pollution or explosions from methane 	<ul style="list-style-type: none"> • Separation and purification is difficult • In many cases, products are considered of low grade • Lack of public acceptance of products 	<ul style="list-style-type: none"> • Set up and maintenance tend to be expensive • Can cause air pollution

Paper 032 – Alternative to SBAQuestion 1

Syllabus References: A: 3.3, 8.1, 8.3

This question mainly tested candidates' knowledge of electrochemistry. The maximum mark available was 26. Most candidates were able to score at least 12 out of 26.

Candidates were provided with information regarding the materials, reagents and the procedure required to determine the heat of neutralization for the reaction of hydrochloric acid with sodium hydroxide.

Part (a) required candidates to read a balance and a thermometer and report the information in a table. Most candidates achieved this and earned at least five of the six marks available for this task.

In Parts (b) to (d), candidates were required to write the chemical equation for the reaction and calculate the mass of solution and the temperature change that occurred based on their readings; calculate the heat change for the reaction and the moles of water that were produced during the reaction; and indicate whether the reaction was exothermic or endothermic.

Although most candidates accurately wrote the equation to represent the reaction between NaOH and HCl, a few used capital and lower case letters incorrectly when writing the formulae. For example, NAOH or NaoH was noted for sodium hydroxide and HCL or Hcl for hydrochloric acid.

The calculation of the mass of the solution and temperature change presented little difficulty for candidates. There were a few candidates who calculated temperature change by subtracting the final temperature from the initial temperature to determine whether the reaction was endothermic or exothermic. The practice is incorrect and candidates should be discouraged from doing so.

Since the required equation was given, calculating the heat change for the reaction presented little difficulty for candidates. However, calculating the moles of water produced in the reaction, a basic mole calculation, proved challenging for far too many candidates. Likewise calculating the heat of neutralization was also challenging. In addition, many candidates neglected to include units in the calculation. Candidates should always be encouraged to work with units during a calculation and to state the final unit at the end.

Too many candidates noted that the reaction was endothermic rather than exothermic. This indicated that there are some misconceptions in this area. Candidates should be able to recognize that the rise in temperature measured is due to the reaction releasing heat and not taking in heat; hence, it was exothermic and not endothermic.

In Parts (e) and (f), candidates were required to indicate possible precautions and sources of errors associated with the experiment.

The two most common answers given in this section were associated with parallax and laboratory safety. In some cases, candidates in trying to describe how they could avoid parallax error, noted that the instruments should be read at 90° rather than at eye level. Although candidates were credited for such answers, it was expected that they would have included some of the possible precautions and sources of error outlined below.

Precautions:

- Pouring liquid down the sides of the stirring rod
- Stirring gently to avoid splashing
- Covering the cup as quickly as possible after mixing

Sources of error:

- Some heat produced could have been absorbed by the container.
- Some heat could have been lost to the room/surroundings.
- Measuring using a measuring cylinder is not as precise as using a pipette.

Candidates were not credited for answers such as choosing apparatus that was not broken, human error, incorrect measurement or wrong temperature reading.

Part (g) tested candidates' ability to determine how a change from a styrofoam cup to a beaker would affect the results. It required the candidates to have a clear understanding of the energy changes that take place in a chemical reaction. Not many candidates demonstrated that they had this understanding. Some candidates recognized that the beaker is a better conductor of heat than the styrofoam cup but could not relate that knowledge to the impact it would have on the experimental heat of neutralization. It was expected that candidates would be able to deduce that since the beaker is a better conductor of heat then more of the heat produced in the experiment would escape to the room before it is measured. Hence, the temperature reading taken would be lower than expected. This lower temperature reading would result in a lower calculated heat of neutralization.

In Part (h), candidates were asked to calculate the mass of solid that would be needed to make up a particular volume of solution of known concentration. Many candidates should have been familiar with this type of calculation but far too many were still having challenges. In some of the scripts, it was evident that candidates were not employing the unitary method. Hence, when the answer was incorrect it was difficult to award partial marks since their reasoning lacked clarity and was difficult to follow.

In Part (i), candidates were asked to adapt a metal stirrer in order to make it more suitable for use in the experiment. Candidates provided a variety of answers. Some of them simply replaced the stirrer with one of plastic or glass rather than adapt the metal stirrer. Several focused on the heat that could be possibly transferred into the solution from the person holding the metal stirrer and not on the heat that could be possibly absorbed from the metal stirrer itself. Hence, the answers spoke to wrapping plastic, cloth or rubber on the handle of the stirrer rather than on the entire stirrer. Marks were awarded only for adaptations that utilized insulating and water-proofing material.

Question 2

Syllabus References: B2: 7.1, 7.2, 7.3

This question was based on qualitative analysis. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid mixture. The majority of candidates earned less than five of the maximum ten marks. This suggests that the candidates had limited knowledge of this area. For example, when told that a few drops of KI solution was added (suggesting that an oxidizing agent was possible), instead of noting that a brown precipitate would be observed many candidates recorded 'a yellow solution or a brown solution'.

Question 3

Syllabus References: B2: 1.2

Candidates were required to plan and design an experiment specifically using the action of heat to distinguish among anhydrous calcium nitrate, anhydrous calcium carbonate and calcium hydroxide which were placed in unlabelled containers. Again, this question was poorly done with the majority of candidates earning less than five out of ten marks.

In many cases, the list of apparatus was incomplete. Most candidates stated that they would need a Bunsen burner and a test tube but made no reference to a test tube holder, for example. The procedures which candidates proposed were varied. It was expected that they would place a small amount of each solid in separate test tubes, heat each separately, record the observations and test the gases produced.

Although candidates were instructed that they must use the action of heat to distinguish the three compounds, some candidates used no heat at all in their procedure. Several of them proposed a procedure based on solubility instead. Many of those who suggested the use of heat either recommended using a water bath or dissolving the salts in water or HCl first before heating.

When asked to state one precaution that should be taken in conducting the experiment, some candidates correctly expressed that they should point the test tubes away from their faces or mentioned one of many safety precautions. Some precautions, however, were not precise; for example, they suggested that one should avoid contaminating the sample or should stand away from the Bunsen flame. A suggestion such as 'making sure that the apparatus was clean' was not awarded any marks.

Many candidates thought that heating a hydroxide would form hydrogen gas and oxygen gas instead of the oxide and steam. The test for CO₂ was well known as well as the colour of NO₂ gas. However, some candidates suggested inferences rather than the observations which were required. For the discussion section, many candidates linked the observations and the inference for the gas to deduce a possible identity for the compound.