

CARIBBEAN EXAMINATIONS COUNCIL

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

JANUARY 2011

**CHEMISTRY
GENERAL PROFICIENCY EXAMINATION**

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GENERAL COMMENTS

The candidates' overall performance on this sitting of the examination was not markedly different from previous performances although there were differences in how the candidates responded to questions on some topics. There were some common areas on both Papers 1 and 2 that posed challenges for the candidates. In addition, there seemed to be several gaps in the candidates' understanding of concepts that led to poor answers.

Some Areas of Concern

- **Weakness in discriminating among concepts**
 - Many candidates confused concepts that sound alike or have different meanings but are related in some way. These included pairs such as addition and condensation polymerization, basic and acidic; saturated and unsaturated groups such as ionic molecular and atomic. Many candidates also loosely referred to activation energy as energy level. Teachers can help students to overcome this hurdle by engaging in teaching for conceptual understanding. Time should be spent helping students to have deep and enduring understanding rather than simply calling to memory how the concepts are defined. Time should be spent helping students to connect ideas so as to help them discriminate better. Teachers should also encourage the correct use of terms during classroom conversation. Many candidates lost KC marks for careless or incorrect use of these terms.
 - Many candidates gave the wrong catalyst for the Contact process and gave instead other catalysts such as nickel and iron which are used in other industrial processes.
- **Unfamiliarity with concepts**
 - Candidates seemed unfamiliar with some concepts that are usually encountered in practical lessons. These include diffusion, sublimation and precipitation.
- **Difficulty thinking in hypothetical terms**
 - Many candidates are unable to think in terms of "a metal M with a valency of 2". They have to work in concrete terms, and often spend time trying to identify the metal M. This is not generally required in these cases and candidates are advised to use their examination time more wisely. Students seem to need additional practice in this level of thinking which will only take place if teachers provide these opportunities in routine classroom assessment.

In this regard, use should be made of past examination questions to provide students with ample practice.

- **Writing and balancing equations**
 - This skill seems to be on the decline once more. Far too many incorrectly written formulae were presented in the scripts.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. The performance on this paper continued to be steady and is comparable with the performance in 2010.

The mean score earned by candidates was 52 per cent with a standard deviation of 10.

Paper 02 – Structured/Extended Response Questions

Question 1

Syllabus References: A: 3.3, 3.4, 3.7, 6.7, 6.8, 6.9, 6.10, 6.12

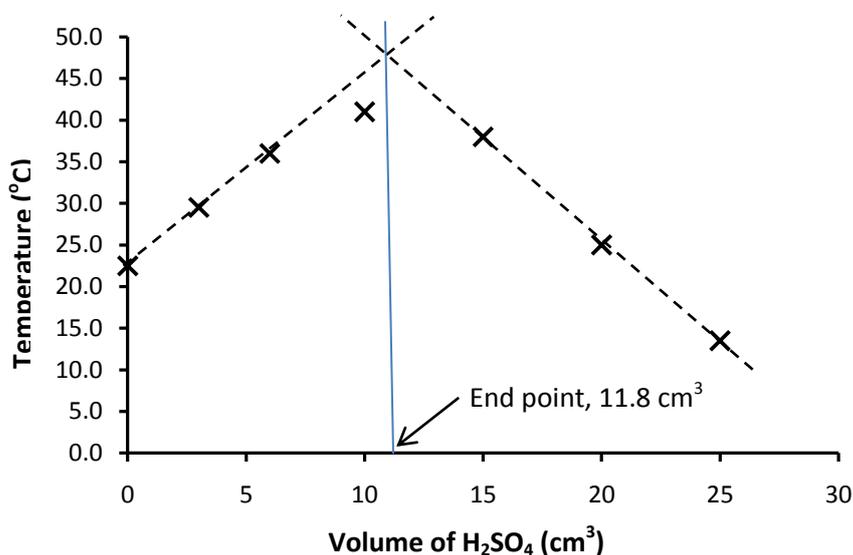
In Part (a), candidates were required to differentiate between a ‘strong acid’ and a ‘weak acid’; determine the end-point in an acid-base titration by the graphical interpolation method from temperature readings obtained when different volumes of dilute sulphuric acid were added to 25 cm³ samples of 2 mol dm⁻³ NaOH; write a balanced equation for the reaction; calculate the number of moles of NaOH used, and calculate the concentration of the sulphuric acid.

The average mark for this question was 8.5 out of 25. Most candidates correctly stated that a strong acid is completely ionized while a weak acid is only partially ionized. Many suggested that potassium hydroxide (a strong base) could be substituted for sodium hydroxide, while many gave incorrect suggestions such as magnesium hydroxide, aluminium hydroxide and calcium hydroxide. The majority of candidates gained the three marks for Experimental Skills (XS) for plotting all seven points correctly on the graph, but many had difficulty in drawing the ‘two lines of best fit’ through the ‘increasing’ and ‘decreasing’ points.

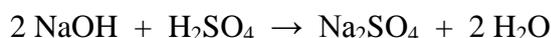
Candidates were required to draw the two lines of best fit through the points and determine, by interpolation, the end point of the acid base reaction. This was the most challenging part of this question and many candidates lost marks for drawing the lines of best fit. Some candidates did not draw the lines intersecting, suggesting that they were unfamiliar with this

procedure for determining end point. A number of candidates failed to balance the common equation between sodium hydroxide and sulphuric acid and so lost marks in this section. Many candidates also had difficulty doing the calculations in (vii) and (iii).

The expected responses for Part (a) are as follows:



Balanced Equation for the reaction:



Number of moles of NaOH used in the reaction:

1000 cm³ of 2 mol dm⁻³ NaOH contain 2 moles
 Therefore, 1 cm³ of 2 mol dm⁻³ NaOH contains (2/1000) moles
 Therefore, 25 cm³ of 2 mol dm⁻³ NaOH contain (2/1000) x 25 = 0.050 moles.

Calculation of the concentration of H₂SO₄ in mol dm⁻³:

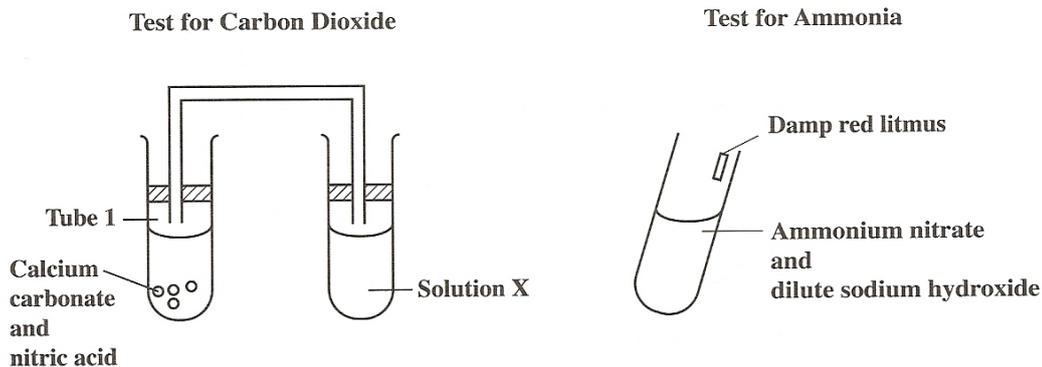
From the equation, 2 moles of NaOH require 1 mole of H₂SO₄
 1 mole of NaOH requires (1/2) mole of H₂SO₄
 0.050 moles of NaOH require (1/2) x 0.050 = 0.025 moles of H₂SO₄

These 0.025 moles of H₂SO₄ are contained in the volume of acid at the end-point (11.8 cm³).

Therefore, 11.8 cm³ of H₂SO₄ contained 0.025 moles of H₂SO₄
 1 cm³ of H₂SO₄ contained (0.025/11.8) moles of H₂SO₄
 1000 cm³ of H₂SO₄ contained (0.025/11.8) x 1000 = 2.1 moles of H₂SO₄

Therefore, the concentration of H₂SO₄ = 2.1 mol dm⁻³.

Part (b) tested candidates' knowledge of laboratory experiments used to identify two gases — carbon dioxide and ammonia — as shown in the following figure.



Candidates were required to (i) identify Solution X; (ii) identify ONE flaw in each set-up; (iii) write a balanced equation for the reaction occurring in Tube 1, and (iv) explain why nitric acid is used instead of sulphuric acid in Tube 1 to obtain a positive test result.

For Part (b) (i), the majority of candidates correctly identified Solution X as Lime Water, $\text{Ca}(\text{OH})_2(\text{aq})$.

One striking **incorrect** response was 'calcium nitrate', which would have been the solution in the other test tube after the reaction was complete.

For Part (b) (ii), many candidates were able to identify two flaws in the set-up for both tests, stating correctly that the delivery tube should be inserted under the surface of Solution X so that the gas would bubble into the solution, and that heat should be applied to the test tube in the test for ammonia gas. Some candidates stated that the litmus paper should not be so 'deep' inside the test tube, so as to avoid splashing of the sodium hydroxide solution onto the litmus paper. Some candidates also stated that there should be a hole in the bung above Solution X so as to prevent pressure build-up and explosion of the test tube. These responses were awarded full marks.

For Part (b) (iii), many candidates recognized that the product of the reaction in Tube 1 was calcium nitrate, but had difficulty writing the formula for calcium nitrate or the correct balanced equation.

A number of candidates gave the incorrect formula of calcium nitrate as $\text{Ca}(\text{NO}_3)$. The expected response is $\text{CaCO}_3(\text{s}) + 2 \text{HNO}_3(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

Candidates were not penalized if the state symbols were omitted.

In Part (b) (iv), candidates' performance indicated that the majority of them were unaware that insoluble calcium sulphate would be formed in sulphuric acid. Some candidates stated that an insoluble salt would be formed but did not explain how the insoluble salt would affect the production of carbon dioxide. This is one example of the need for teachers to help students understand rather than recall a process.

If sulphuric acid is used, insoluble calcium sulphate would form around (on the surface of) the calcium carbonate granules, slowing down and eventually stopping the generation of carbon dioxide. Enough carbon dioxide would not be generated to produce a positive test result.

Question 2

Syllabus Objectives A: 1.1, 1.2, 8.1, 8.2, 8.3

Part (a) tested knowledge of diffusion of solids in liquids and the effect of heat on the rate of diffusion of solids in liquids.

Candidates were required to state the colour of the potassium permanganate and to explain that after 24 hours the colour would spread throughout the water to make a homogeneous mixture. Beaker B, which was heated to 50 °C, would become purple before Beaker A as the higher temperature would increase the internal consistency of the particles causing them to diffuse faster.

Most candidates knew the colour of the potassium permanganate but many lost marks as they did not describe the changes that would take place in the beakers over time. Responses were somewhat superficial such as “the solution turned purple” with little appreciation shown for the fact that this was a gradual process and that it did not take place suddenly. While most candidates scored marks for correctly stating that the contents of Beaker B would become purple before the contents of Beaker A, many again lost marks for the superficial responses given for the reasons for the differences. A common example was “The heat causes the permanganate to dissolve faster”. Candidates were required to explain that the higher temperature resulted in internal energy of the particles and that it was as a result of the increased internal energy that the particles were able to diffuse faster in Beaker B.

Part (b) tested candidates’ knowledge of energy changes. Candidates were required to draw the energy profile diagram for the heat change when 8 grams of ammonium nitrate was dissolved in water and to calculate the heat of solution of ammonium nitrate.

The energy profile diagram expected for ammonium nitrate was that of an endothermic reaction. Candidates were required to use the formula $Q = mC\Delta T$ to calculate the heat change for 8 grams of ammonium nitrate and hence the heat change for one mole.

Far too many candidates identified the heat change as exothermic instead of endothermic. Generally, the energy profile drawings were poor. Those candidates who managed to score marks got the relative positions of the reactants and products and/or the activation energy correct. The majority of the candidates were unable to label the axes for the energy profile diagram. Most referred to the x-axis as “time” instead of “reaction pathway”.

In calculating the heat change for the reaction, the major challenge seemed to be determining the correct mass to be used. Some candidates used the mass of the ammonium nitrate while some added the 8 grams of the potassium nitrate to the mass of the water. The correct mass

to be used for this calculation, in which 50 cm^3 of water was used to make the solution, was 50 grams. The majority of candidates were able to convert the mass in grams to kilograms.

Very few candidates stated the correct assumption for the calculation and stated instead an assumption that related to the conduct of the experiment that no heat was lost to the environment. While this may have been relevant for the conduct of the experiment, the more appropriate assumption for the calculation was that the heat capacity of the solution was the same as that of water or that the density of the solution was the same as that of water.

Question 3

Syllabus References: B1: 2.2, 2.3, 2.4, 2.5, 2.6

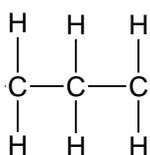
Candidates were tested on the nomenclature and structure of an alkane and an alkene, the reaction of alkenes with bromine, the identification of homologous series from structures, and the solubility of compounds in water, based on their structures.

The average mark on this question was 6.5 out of 15, with approximately 40 per cent of candidates scoring 8 marks or more. This shows an improvement, when compared to previous examinations, on questions on organic chemistry.

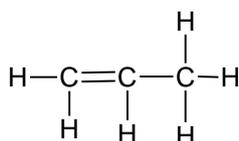
In Part (a), candidates were given the molecular formulae of two hydrocarbons, propane (C_3H_8) and propene (C_3H_6), and were required to give the fully displayed structures and names.

Many candidates were able to deduce the names of both hydrocarbons, and the structure of propane, but had difficulty with the structure of propene, and so, were able to obtain three of the four marks for Use of Knowledge.

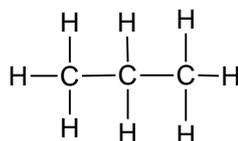
Many candidates had the following incorrect structure for propene:



The correct structures and names are as shown below:



(A) propene



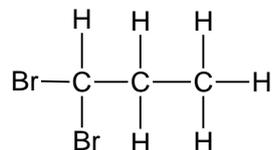
(B) propane

For Part (b), candidates were required to indicate which of the hydrocarbons — propane or propene — would react with bromine by (i) stating the observation for the reaction, (ii)

writing a chemical equation for the reaction, and (iii) drawing the *fully displayed* structure and giving the name of the product of the reaction.

The responses indicated that the majority of candidates were aware of the colour of bromine, but unfamiliar with the reaction of alkenes with bromine.

A number of candidates gave the incorrect structure of the reaction product as

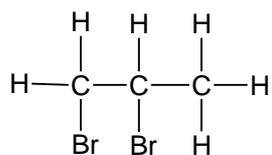


which does not account for the addition of bromine *across* the double bond of the alkene.

For Part (b) (i), the response which was expected is that the red-brown colour of the bromine would disappear, or the solution would be decolourized, or the solution would change from red-brown to colourless.

The correct equation for Part (b) (ii) is $\text{C}_3\text{H}_6 + \text{Br}_2 \rightarrow \text{C}_3\text{H}_6\text{Br}_2$

For Part (b) (iii), since bromine (Br_2) adds across the double bond,



the correct structure of the product is 1,2 dibromopropane.

In Part (c), candidates were given the structures of propanol (an alcohol), methyl propanoate (an ester) and butanoic acid (a carboxylic acid), and were required to (i) write the names of the homologous series to which each belonged, and (ii) indicate, with reason, which *two* are soluble in water.

The majority of candidates were able to identify at least one of the three homologous series correctly, while less than 20 per cent correctly identified all three. Some candidates gave the names of the three compounds instead of the homologous series. The majority of candidates recognized that the presence of polar groups (e.g. OH) on a molecule would aid the solubility in water, a polar solvent.

Some candidates were unable to distinguish between the ester and the carboxylic acid and wrote 'acid' instead of carboxylic acid.

Candidates also incorrectly referred to the OH group as a hydroxide ion (OH^-).

Compounds	Homologous Series
Propanol	Alcohols
Methyl propanoate	Esters
Butanoic acid	Carboxylic acids

Question 4

Syllabus References: A: 5.5, 6.1, 6.2, 6.3, 6.4; B2: 4.1, 4.2

Candidates were tested on their knowledge of the ‘clarifying’ and ‘crystallization’ steps in the manufacture of cane sugar, the variation of atomic radii and reactivity in Group II elements, the relative reactivity of the halogens, and the acidic/basic properties of the oxides of non-metals/metals.

This question was poorly done, with an average mark of 4 out of 15; 13 per cent of the candidates scored 8 marks or more.

In Part (a), candidates were required to outline what happens in the ‘clarifying’ and ‘crystallization’ steps in the extraction of sucrose from the juice of sugar-cane. The majority of candidates did not appreciate the *clarifying* step. Many candidates had a better understanding of what happens during *crystallization*, in general, but not specifically to the process as it relates to the production of sugar.

Candidates incorrectly outlined clarifying as washing and filtering to remove dirt and indicated that clarifying is where the impurities of sugarcane juice are removed. They also inaccurately stated that juice is heated and left to crystallize.

Candidates were expected to state that during *clarifying* the sugarcane juice is neutralized by the addition of calcium hydroxide and heated. Insoluble impurities are precipitated in the form of insoluble calcium salts. In *crystallization*, pure sugar crystals are added (a process known as seeding) to the thick, supersaturated syrup to cause the formation of crystals.

In Part (b) (i), candidates were required to give a reason for the increase in atomic radius (i.e. the size of the atom) as Group II is descended, from magnesium to barium.

Many candidates recognized that an increase in the number of electron shells (energy levels) occurred as the group is descended, but failed to state that shielding of valence electrons from the nucleus, by the electrons in the filled inner shells, would result in an increase in atomic radius.

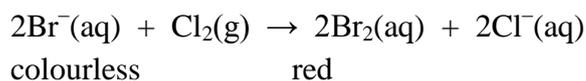
For Part (b) (ii), candidates were required to explain the higher reactivity of barium, when compared to magnesium, towards water, using the table of ionization energies that was given.

Most candidates correctly indicated that the higher reactivity of barium was due to its lower ionization energy (as seen in the table), but failed to state that the lower ionization energy is as a result of the valence electrons being more easily lost, hence the higher reactivity.

For Part (c), candidates were required to indicate whether (i) chlorine gas and (ii) iodine crystals would react with an aqueous solution of sodium bromide.

This part of the question was fairly well done. Most candidates correctly indicated that a reaction would take place with chlorine gas, but there would be *no reaction* with iodine.

The correct equation, showing the oxidation of bromide (Br^-) to bromine (Br_2) by chlorine gas ($\text{Cl}_2(\text{g})$) is:



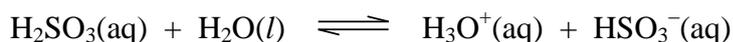
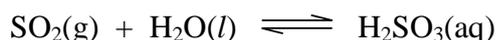
Part (d) required candidates to distinguish between two aqueous solutions — one of sulphur dioxide and one of sodium oxide. Specifically, they were asked to describe a test that could be used to identify the solution formed with sulphur dioxide, and to write a balanced equation to support the test.

Part (d) was fairly well done, with most candidates recognizing that sulphur dioxide is an acidic gas. Candidates gave a variety of correct responses (apparently from their practical experience), including:

- Heat the solution and test the gas with damp blue litmus paper.
- Test the solution with blue litmus paper.
- The solution would be red/orange with universal indicator.

Sulphur dioxide is an acidic gas which dissolves in water to give an acidic solution. A simple test is to test the solution with blue litmus paper, which would change to red.

Acceptable equations were:



Question 5

Syllabus objectives: A: 4.7; B2: 1.2, 1.3, 3.1

Part (a) tested candidates' knowledge of the Contact Process. Candidates were required to

- describe the processes involved in the first two stages of the process,
- identify the conditions for the production of sulphur trioxide and
- explain the use of sulphuric acid as a solvent for sulphur trioxide instead of water.

Candidates were able to give a description of the two steps involved in going from sulphur to sulphur trioxide as well as the relevant chemical equations. In Step 1, it was expected that candidates would state that sulphur was burnt or heated in air. For Step 2, the required response was that the sulphur dioxide from step 1 was "burnt in excess oxygen" to make

sulphur trioxide. Again, responses that were not specific — such as sulphur “reacted” or “combined” with the air — were not awarded full marks.

While most candidates found little difficulty with the equations for Step 1, the equation for step 2 was generally incorrect. Very few candidates knew all the conditions for Step 2: viz. – 1–2 atm., 450 °C and V_2O_5 catalyst. Many got at least one mark for this section.

Very few candidates knew that the reaction for SO_3 with water was highly exothermic and that a highly corrosive mist would form as a result and hence, conc. sulphuric and not water was used to dissolve the sulphur trioxide.

The writing of the ionic equation for the reaction of carbonate with an acid was poorly done. Many candidates seemed unable to write the equation in terms of H^+ ions only and had to write the equation using the formula of a hypothetical acid such as HX and sodium carbonate.

Part (b) tested candidates’ knowledge of the structure and subsequent properties of diamond and graphite.

This question posed unexpected difficulties for many candidates as they knew the general structure of diamond and graphite but were unable to explain how the structure of diamond made it strong and therefore suitable for cutting whereas the structure of graphite was layered and flaky and hence not suitable for cutting. Candidates were required to refer to the tetrahedral structure of diamond with its strong covalent bonds contributing to its hardness while the weak inter-layer bonds of graphite leads to it being flaky or soft and therefore not suitable for cutting. For the most part, candidates described the structure – loosely in terms of strong bonds for carbon and often incorrectly as weak bonds in graphite.

Question 6

Syllabus Objectives: C1 1.3, 1.4, 1.9, 1.10

In Parts (a) and (b), candidates were tested on their knowledge of the constituents of flour and the action of yeast in bread making. They were also required to compare the actions of baking powder and yeast in making dough rise.

While many candidates seemed to have a general knowledge of the process of bread making, it was clear from the responses that very little attention was being given to the chemistry of the steps in bread making. This limited interpretation of the requirements for responses saw many candidates writing a lot of information on the actual process of bread making but being awarded little marks as they did not include the chemical principles for carrying out the steps.

Additionally, the candidates knew very little of the chemical equations required for the reactions and many were unable to balance the equations. There were many careless mistakes with representing the correct formula of some important compounds involved in the process such as glucose and maltose. It was also clear from the responses that students need

additional help in providing answers to questions that require comparing processes. The tendency was to describe and not to compare the actions of yeast and baking powder.

Many candidates were unable to name one other major component of flour and many identified “wheat” and “gluten” as other major components of flour. While gluten is produced when flour undergoes some amount of mixing with water, gluten is not considered a major component of flour. The correct responses for that section were proteins, fat or moisture.

Candidates lost marks for not identifying the fact that both baking powder and yeast produce carbon dioxide when they are used as raising agents but the process by which the CO₂ is produced is different for the two substances. Whereas the yeast produces the carbon dioxide as a result of the actions of an enzyme, the production of CO₂ from baking powder is based on an acid-base reaction.

Many candidates were unable to provide a clear explanation of how the yeast caused the dough to rise during baking. The responses to this section were particularly poor. The expected response was that the carbon dioxide when produced was trapped in the dough but the gas expanded on heating, pushing up the dough in a bid to escape thus causing the dough to rise. Many referred to the fact that CO₂ aerated the dough — a common phrase found in many texts — but the response required more than this description. There should have been an explanation of the phenomenon.

The two equations required were



Part (c) of the question tested candidates’ knowledge of the action of hydrogen carbonate and heat on the concentration of acids.

A fair number of candidates were able to apply their knowledge of acid/baser reactions to answer this part of the question. However, they did not provide a suitable explanation of how heat affected the vitamin C content and hence the acidity during stewing. Many referred to the heat as “denaturing the enzyme” — another common phrase found in many texts referring to the action of heat on enzymes. Candidates seemed to confuse enzymes with vitamin C.

The expected response was that while sodium hydrogen carbonate, the chemical in baking soda, would reduce the acidity of in tamarind juice, the heat would destroy the vitamin C in cooking and hence, there would be no need to add the HCO₃ in that case.

Paper 03/2 – Alternative to SBA

Syllabus References: A 1.2, 3.3, 6.0, 8.3, B2. 7.1, 7.2, 7.3

Question 1

This question tested candidates' knowledge of the solubility of sulphates and the experimental details required for the preparation of an insoluble salt. It also tested their ability to calculate percentage yield and their understanding of the method of determining the melting point of a solid. The maximum mark available was 26. Almost all of the candidates were able to gain at least five of the marks.

Part (a) required candidates to

- (i) describe a test to distinguish between sodium sulphate and lead(II) sulphate
- (ii) prepare a dry sample of lead(II) sulphate
- (iii) calculate the theoretical yield of lead(II) sulphate to be obtained from a given mass of lead(II) nitrate and sulphuric acid.

Many candidates did not recognize that the difference between the two salts related to their solubility in water. As a result many of them attempted chemical tests such as the addition of hydrochloric acid, aqueous sodium hydroxide or aqueous potassium iodide in order to test for the presence of Pb^{2+} ions in solution. This lack of knowledge was also evident in their preparation of the salt where they tried to crystallize the salt from an aqueous solution. Even those candidates who recognized that lead(II) sulphate was insoluble lost a mark for not first preparing an aqueous solution of lead(II) nitrate from the solid that they were given. A surprisingly large number of candidates seemed to think that filtration required only filter paper and left out the funnel when listing their apparatus.

A large percentage of the candidate population could not write the simple equation for the reaction between lead(II) nitrate and sulphuric acid. Many candidates thought that the products of the reaction included water, nitrogen(IV) oxide and hydrogen gas. Others could not write the formula for nitric acid. In the calculation of the theoretical yield of the lead(II) nitrate, most candidates showed an aptitude for calculating molar mass and the number of moles of a substance. Unfortunately, many tended to divide the mass of lead(II) nitrate given by the molar mass of lead(II) sulphate in order to get the number of moles of lead(II) sulphate. Calculations were not clearly set out and oftentimes no reference was made of the mole ratio between the nitrate and the sulphate.

In order to distinguish between sodium sulphate and lead(II) sulphate it was expected that water would be added to separate samples of the salt, so that the one that dissolved would be sodium sulphate and the insoluble one would be identified as lead(II) sulphate.

When preparing lead(II) sulphate, four steps were required:

- addition of distilled water to the lead(II) nitrate to form a solution

- mixing the solution of lead(II) nitrate with the sulphuric acid provided
- filtering off the insoluble lead(II) sulphate
- washing the residue with distilled water and drying in an oven

In the calculation of the theoretical yield of lead(II) sulphate from 3.31 g of lead(II) nitrate, candidates were required to calculate the number of moles of lead(II) nitrate, that is, $3.31/331$, use the 1:1 mole ratio between it and lead(II) sulphate to determine that the number of moles of lead(II) sulphate that were produced was therefore 0.01 and hence multiply this number by the molar mass of lead(II) sulphate which is 303 to obtain a mass of 3.03g. The percentage yield was then $2.25 / 3.03 \times 100$.

Part (b) required candidates to

- draw a diagram of the arrangement of the apparatus for determining the melting point of stearic acid
- use the data provided from such an experiment to plot a graph that would allow them to determine its melting point
- account for the shape of the graph with increasing temperature in terms of change in state of the stearic acid.

The diagram for determining the melting point of stearic acid should have been labelled and should have included a source of heat, a water bath and a container with stearic acid which had a thermometer immersed in the acid. The container should have been in the water bath.

The melting point of the acid, from the graph, was 55 °C.

There were three distinct regions to the graph. The first upward slope was the result of increasing temperature causing an increase in the internal energy of the particles so that the particles began to move away from each other. At the level section of the graph the solid was being converted to liquid. The increase in temperature did not cause the temperature of the particles to rise because the energy was being used to break the bonds and convert the solid to the liquid. Once melting was completed, the temperature of the liquid began rising again as the particles continued to increase their movement.

Question 2

This was a simple qualitative analysis question that tested Syllabus Objectives B2. 7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when an unknown solid, Y, was added to water, the mixture was filtered and tests were performed on the filtrate and residue. A maximum of 10 marks were awarded for this question.

Responses to the question were better than in previous examinations, although overall the question was poorly done. Some candidates excelled getting eight and nine marks out of the allotted ten marks. A large number of candidates chose to omit the question. The majority of those who answered the question seemed unfamiliar with the bright yellow colour of the lead(II) iodide precipitate and with the solubility of the copper(II) hydroxide precipitate in excess aqueous sodium hydroxide and ammonia. The blue colour of copper(II) hydroxide and

the white precipitate that carbon dioxide produced with lime water were, however, very well known. Unfortunately, too many candidates still refer to lime water turning cloudy/milky in the presence of carbon dioxide. Too many candidates still write observations that give either a colour without a state or a precipitate without a colour.

Candidates were expected to record the presence of a white precipitate, soluble in excess sodium hydroxide, in Test (ii). A yellow precipitate should have been observed in the reaction with potassium iodide while there should have been no visible reaction with silver nitrate. In Test (v), it was expected that candidates would record effervescence and a white precipitate when the gas was bubbled through lime water. A blue precipitate that was insoluble in excess sodium hydroxide but which dissolved in excess ammonia giving a deep blue solution were the expected observations for Tests (vi) and (vii) respectively.

Question 3

This question tested the planning and design skill as related to Syllabus Objective A 8.3. Candidates were required to plan and design an experiment to determine whether methylated spirit and kerosene produced the same amount of energy on combustion. The question was poorly done. Most of the candidates who attempted the question scored less than 5 of the 12 marks awarded. Candidates were given adequate guidance in the stimulus material at the beginning of the question. Despite this, many candidates did not appear to have read the data carefully and proposed improbable procedures.

A creditable number of candidates scored at least one mark for the procedure. Only a few, however, realized that the measurements that had to be taken should form part of the procedure. Some candidates used a procedure that did not allow them to collect data that could be subjected to mathematical treatment. For example, the fuels were allowed to heat a fixed volume of water for a specific length of time and the temperature of the water was taken after the time period. The fuel that heated the water to the higher temperature was said to have the higher heat of combustion.

The diagram of the apparatus to be used in the experiment was fairly well done by most candidates. Some candidates tried to heat the liquids whose heat of combustion was to be measured directly indicating clearly that they had not read the information at the beginning of the question where it was stated that “ the heat of combustion can be readily determined from experimental data obtained from the heating of water by the fuels”. Other candidates lost a mark for not immersing the bulb of the thermometers in the water. Still others did not give diagrams of assembled apparatus.

Some candidates misunderstood what was required in Part (c) as data to be collected. A common error was to give temperature change as the answer instead of the initial and final temperature of the water. Similarly, mass of fuel burnt was given instead of the initial and final mass of the burners containing the fuel. Some confusion also existed between the data to be collected and the variables in the experiment. Calculation of $E_H = mC\Delta T$ was well known.

Not quite as familiar was the calculation for ΔH in which E_H was divided by the number of moles.

Most candidates were able to identify sources of error in the experiment.

A possible response that would be awarded full marks is given below.

Procedure

- Measure out 100 cm³ of water and place it in a beaker.
- Place the beaker on a tripod and measure and record the temperature of the water.
- Weigh a spirit burner filled with methylated spirit.
- Place the burner under the water and light it. Allow it to heat the water for 10 minutes.
- Extinguish the burner, record the temperature of the water and reweigh the burner.
- Repeat the experiment using a burner filled with kerosene.

Diagram

The diagram should include

- a container of water on a tripod
- thermometer immersed in the water
- spirit burner containing fuel under the water

Data to be collected

- initial and final temperature of water
- volume/mass of water
- initial and final mass of burner

Calculation of Heat of Combustion

$$E_H = mC\Delta T$$

$$\Delta H = E_H/\text{no. of moles of fuel used}$$

Sources of error

- heat loss to the environment
- loss of mass of fuel through wick of burner before it is reweighed