CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN SECONDARY EDUCATION CERTIFICATE EXAMINATION
MAY/JUNE 2006

CHEMISTRY

CHEMISTRY
GENERAL PROFICIENCY EXAMINATIONS
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The Structure of the Examination

The examination consisted of three written papers. The contributions of these papers were as follows:
Paper 01 (25 %), Paper 02 (30 %), and Paper 03 (25%). Paper 04, the School-Based Assessment (SBA), contributed 20%.

Paper 01 consisted of 60 compulsory multiple-choice items based on the specific objectives in Sections A and B of the syllabus. Items were assessed under the profile, Knowledge and Comprehension (KC).

Paper 02, a structured essay paper, consisted of five compulsory questions based on the objectives specified in Sections A and B of the syllabus. Question 1 was a data analysis question. Candidates were assessed under three profiles, Knowledge and Comprehension (KC), Use of Knowledge (UK) and Experimental Skills (XS).

Paper 03, an extended essay paper, was divided into three Sections, A, B, and C, with each section consisting of two questions. Candidates were required to answer one question from each of the three Sections. Section C of the paper tested Section C of the syllabus. Candidates were assessed under the profiles, Knowledge and Comprehension and Use of Knowledge.

Paper 04 involved the continuous assessment of candidates by teachers over a two year period. Samples of candidates' laboratory books were externally moderated by CXC. This was used as the basis for moderation of all SBA marks submitted by teachers.

General Comments

A total of 11 194 candidates were entered for the examination representing a 5% increase over the 2005 examination candidate population. Candidates' performance on Paper 01 was marginally higher than that of 2005 while performance on Paper 02 was significantly better. However, the performance on Paper 03 showed a decline over performance in 2005.

While there was an improvement in the overall performance of candidates, there are some weaknesses that need to be addressed. Candidates have problems understanding and analyzing questions, resulting in superficial responses to questions. More specific comments on each paper are outlined below.

DETAILED COMMENTS

Paper 01 – Multiple Choice

Performance in this paper continues to be generally good. The marks ranged from 0-57.
Candidates experienced difficulties with items based on the following objectives:

- A4.3 - Structure and Bonding
- A6.2 - Periodicity of Elements
- A8.1 - Energy and Energetics
- B1.4.2 - Polymers
- B2.2.2 - Extraction of Metals

Paper 02 –Structured Essay

Note: These comments should be read in conjunction with the question paper.

Question 1.

Part (a) required candidates to complete a Table to show the solubility of a salt X at various temperatures, plot a graph of the data, make deductions and do calculations based on the data. Part (b) tested candidates' knowledge of qualitative analysis, requiring them to complete observations or inferences for tests on an unknown solid, Q.

Part (a) involved the assessment of UK and XS profiles and was the more popular part of the question. In Part (a) (i), the majority of candidates were able to correctly complete the Table and obtained full marks for this section. However, the following should be noted:

- Some candidates had major problems reading the thermometer values, and in general all graduated values. (They could not work out the separation values).
- A few candidates stated fraction values to be used to plot a graph.
- Few candidates had problems substituting the values to find solubility.

Part (a) (ii): The majority of candidates obtained full marks for plotting the correct points on the graph. However, the following should be noted:

- Many candidates did not draw a graph after plotting the points, thus indicating deficiencies in mathematical skills (type of graph required for the relationship given).
- In a few cases, candidates used rulers to draw curves and pencils with thick points or pens.
- Candidates need to get more practice in drawing graphs using given scales. (Following instructions).

Part (a) (iii): Candidates performed fairly well in this section. However, the following should be noted:

- Candidates were expected to connect solubility with temperature as a direct relationship graph and this needs more practice.
- Candidates referred to rate of dissolving, not increased solubility of X.

Part (a) (iv): Many candidates obtained full marks in this section. However, the following points were noted:

- A few candidates did not know how to read the value at 60 °C.
- The volume of water was incorrectly calculated.
- Candidates need more knowledge in converting g to cm^3, and to follow instructions given.

Part (a) (v): Many candidates obtained full marks. However, the following should be noted:

- Many candidates read off 40 °C and used this value as the correct answer.
- Many candidates did not recognize the difference between the solubilities at 60 °C and 40 °C in order to calculate the mass of precipitate formed.

Part (b): This section was either fully answered or not answered at all.

- Most candidates gave the correct observation for Test (ii).
- Many candidates rewrote the inference from Test (ii) for the inference for Test (iii). This was incorrect.
- Candidates need more practice at writing ionic equations, especially for qualitative analysis.
- Candidates loosely used "halide" to mean "halogen", gave answers such as 'no halogen present' instead of the correct answer of 'no halide ions present'.
- Many incorrectly gave the formula for a carbonate as CO_3^- and CO_2^-.
- Although many candidates correctly wrote the observation of a blue precipitate for Test (vii), the following points were noted:
  - Candidates did not give the correct observation when excess aqueous NaOH was used in this test.
  - Many candidates stated that a blue solution was formed or that a blue mixture was formed, and not a precipitate.
  - An ionic equation was given as $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$, and not $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$, which was the correct answer.

Part b (viii): Many candidates gave a correct response of "a deep blue solution" for the observation, but stated "deeper blue in excess". Many candidates couldn't distinguish between Tests (vii) and (viii), and gave the same answer for both parts.

Question 2.

This question tested the ability of the candidates to:

- Describe the structure of atoms
- Deduce the number of subatomic particles in an isotope
- Define an ionic crystal
- Draw the crystal structure of sodium chloride
- Explain differences in the physical properties of ionic and covalent substances
- Relate the structure of crystals to their properties.

While most candidates appeared to be familiar with the topic being tested, in general they scored few marks in their responses.

Part (a) (i): This question required candidates to know that different isotopes of an element would have similar chemical properties and to explain that these properties depended only on the number of valence electrons. Most candidates were able to score both marks for this section. However, several of them were unable to provide a proper explanation. Common errors included explaining the similarity in chemical properties in terms of atomic number, different properties based on different masses, suggesting different rates of chemical reaction and discussions about isotopes and radioactivity.

Part (a) (ii): This question required candidates to deduce the number of electrons, protons and neutrons on a given anion of chlorine. The majority of candidates were able to score at least one mark, usually the number of protons. Fewer candidates were able to score the marks for the number of electrons and neutrons. Common errors included ignoring the charge on the ion and inferring that the number of neutrons would be equal to the number of protons.

Part (b) (i): This question required candidates to explain the term 'ionic crystal'. Only a minority of candidates were able to score at least one mark, the most popular responses being a lattice/three-dimensional arrangement of ions and ionic bonding between charged particles. Fewer candidates described the strong electrostatic attraction between cations and anions. Common errors included describing the crystal in terms of ionic bonding between metals and nonmetals, describing the process of crystallization and giving examples of ionic crystals.

Part (b) (ii): This question required candidates to draw the arrangement of Na^+ and Cl^- on a cube. The majority of candidates placed alternate ions on the corners of the cube and on the edges or faces of the cube. Fewer candidates placed alternate ions on both edges and faces of the cube. Even fewer placed alternate ions on both edges, faces and in the centre of the cube. Common errors included similar ions placed adjacent to each other and drawing a random array of ions.

Part (c) (i): This question required candidates to explain the difference in the melting points of sodium chloride and chlorine. Only a minority of candidates stated that the forces of attraction between the particles of sodium chloride were stronger than that between particles of chlorine. Fewer candidates stated the types of bonding present in the two substances. Common errors included statements that ionic bonds are stronger that covalent bonds, that compounds have higher melting points than elements and explaining the difference in terms of heat energy requirement for melting.

Part (c) (ii): This question required candidates to explain the difference in the melting points of magnesium oxide and sodium chloride. Many candidates correctly identified the ions present and were awarded a maximum of two marks. Fewer candidates explained the difference in terms of the size of the charges on the respective ions. Common errors include explanations based on the relative reactivity of magnesium and sodium, and that magnesium oxide had a stronger bond than sodium chloride and that sodium chloride had intermolecular forces.

Question 3.

Candidates were required to answer questions given the structural formulae of four organic compounds from different homologous series. In addition, candidates were given a flow chart involving an unknown reactant **E**, and unknown reactant **F**, and three unknown chemical processes related to organic chemical reactions. Questions were then asked based on reactions in the flow chart. Generally this question was fairly well done.

Parts (a) (i) and (ii): These parts of the question required candidates to name (using given labels) the structures of organic compounds belonging to the same homologous series, giving a reason for doing so. Most candidates were able to correctly identify **A** and **C** as belonging to the same homologous series of alcohols, but some included **B** in their answers, probably because in structure B, the functional group of the organic acid contains the OH group as part of the carboxylic acid group. Many candidates were able to state the homologous series to which the structures in Part (i) belong, this being the alcohols. The required answer was that they have the same functional group (-OH) or the same general formula, $C_nH_{2n+1}OH$. Several candidates lost a mark because they incorrectly referred to the functional group of the alcohols as a hydroxide group, an ion, a hydroxy ion, hydroxyl atom, or a hydroxyl molecule.

Part (a) (iii): This section required candidates to draw and name two structural isomers of the compound pentan-1-ol. The isomers expected included those of pentan-2-ol and pentan-3-ol as well as branched structures of butanol and propanol. This part of the question proved to be very challenging to many candidates. Structures were drawn with covalent bonds or hydrogen atoms missing. A common error was for candidates to draw bent structures of the given structure of compound C as isomers, not realizing that the naming of the isomers is based on the <u>longest continuous</u> carbon chain. Some candidates included –C=C- double bonds in their structural formulae, as well as cyclic compounds as possible isomers not realizing that such structures were wrong answers.

Part (b) (i): This part of the question required candidates to recognize and state the reactant and the reaction conditions for the dehydration reaction of an alcohol. The correct answer was either concentrated sulphuric acid at 170-180 °C or passing the vapour of the alcohol over hot aluminium oxide. This question was not well done. Few candidates gave the correct complete set of reagents and conditions. Some errors included:

- H_2SO_4 as the reagent without specifying that it must be concentrated
- H_3PO_4 at 300 °C as possible reagent/reaction conditions. These however, are the reagent and conditions for the hydrolysis reaction for the conversion of ethane to ethanol (compound **E**).
- Not stating the correct temperature, just simply writing heat as the answer.
- Giving ethanol as the reagent rather than concentrated sulphuric acid.

Part (b) (ii): Many candidates were able to correctly name the process involved in this reaction as fermentation or anaerobic respiration, although some candidates named the process as respiration, hence they failed to gain the mark.

Part (b) (iii): This question required candidates to recognize that the burning of an organic compound in air is a combustion reaction, which produces carbon dioxide and water. Once **E** was identified as ethanol, candidates were expected to write a balanced equation for the combustion of **E**. Many candidates were able to give the formula or draw the structure of ethanol to gain the mark. Many, however, failed to identify compound **F** as CO_2. Some responses suggested that **F** was ethanoic acid. Many candidates were able to secure the third mark by writing the correct balanced equation for the reaction.

Part (b) (iv): This question required candidates to draw the full structural formula of the ester formed from substance **B** (propanoic acid) and substance **E** (ethanol) in the flow chart. Many candidates found this question challenging. Some drew structures with the correct ester linkage, but with incorrect alkyl groups. A considerable number of candidates drew structures that did not show the ester linkage at all.

Question 4.

This question was fairly well done with about 50% of the candidates gaining more than six marks. It tested the candidates' knowledge of the following concepts and principles:

- Reactivity of metals with acids (activity series)
- Ability to write balanced equations
- Covalent bonding
- Ability to draw dot and cross diagrams for covalent compounds
- Knowledge of atomic structure and the periodic table for placement of an element based on atomic number.

Part (a) (i): Many candidates were able to identify calcium as the most reactive metal with HCl. Few candidates chose Al and some chose Be, but they were awarded no marks. This indicated to the examiners that the topic of activity series of metals was well covered by teachers. However, a few candidates incorrectly wrote Ca^{2+} as the answer, hence they were penalized.

Part (a) (ii): Many candidates wrote the correct equation for this section, however, there is a continuing problem with candidates writing wrong formulae, for example, CaCl, Hcl, and HCL; and writing hydrogen gas as 2H instead as H_2. There were also a few unbalanced equations. Teachers are encouraged to teach the correct formulae and equation writing.

Part (a) (iii): This section proved to be difficult for many candidates. There was a failure to recognize a difference in the reaction of Ca with HCl and H_2SO_4 based on the difference in the solubilities of $CaCl_2$ and $CaSO_4$, and the effect this property has on the completion of the reaction. Some candidates stated a difference based on (i) one acid being stronger/weaker than the other and (ii) reaction will be slower with H_2SO_4 instead of vigorous initially, but then slowing down as the insoluble $CaSO_4$ precipitates out, until reaction stops altogether (not going to completion). Candidates also failed to link the difference to the fact that H_2SO_4 is dibasic and hence its reaction will be faster with Ca. Candidates tended to miss the part of the question "observable changes" and instead listed the products formed.

Part (b) (i): Some candidates ran into difficulties by selecting elements for which the bonds formed were difficult, example, C and Si, Al and P. In teaching this topic, dot and cross diagrams involving only the outer electrons make it easier for structures showing bonding to be drawn accurately. A few candidates opted to draw all electron shells of Br, but not knowing the configuration of Br. Other incorrect answers included incomplete drawings, incomplete octets, incorrect number of bonds between atoms. A few candidates tried to form covalent bonds between Na and Ca.

Part (c): Some candidates placed X correctly in Group I and Period 4. A few candidates placed Be in Period 1, and hence described X as being in Period 3. Electronic configurations make it easy for elements to be correctly placed and it should be emphasized when teaching this topic, that the number of valence electrons places an element in a particular group; while the number of occupied shells places the element in its correct period. An atomic number of 19 gives an electronic configuration of 2,8,8,1, where there are four shells (Period 4), with the outer shell having one electron, hence that atom is based in Group 1.

Question 5.

Part (a) (i): Many candidates were able to respond correctly by writing any base/any ammonium salt or the chemical name/chemical formula of a base or an ammonium salt. It is noteworthy that the chemical formulae were written incorrectly frequently. There was much confusion between NH_3 and NH_4^+ as formulae for the ammonium ion.

Part (a) (ii): A significant number of candidates were able to correctly identify diffusion as the process notwithstanding that some had no knowledge of the answers. Other responses included Brownian motion and sublimation or evaporation.

Part (a) (iii): Numerous candidates experienced problems with "the suitability of using moist blue litmus paper". This simply required recognition of the alkaline nature of ammonia. Hence, using blue litmus would be unsuitable and would be unaffected by ammonia gas. For some candidates, suitability meant blue litmus could be used to test for ammonia. Despite recognizing the alkaline nature of ammonia, numerous suggestions were made that blue litmus would turn red. Other candidates suggested that moist red litmus should be used and ammonia would turn it blue.

Part (a) (iv): This section required candidates to describe **ONE OTHER** chemical test to identify ammonia and to write a balanced equation to represent the chemical test. Concentrated HCl or hydrogen chloride gas on cotton wool balls held close to a test tube with ammonia produces dense white fumes was the expected answer. Some candidates gave answers such as white precipitate and dense fumes. Other answers included ammonia bubbled into aqueous copper(II) to give a deep blue solution/blue precipitate; and ammonia bubbled into a zinc salt solution to produce a white precipitate followed by a colourless solution. A number of candidates also suggested bubbling ammonia into dilute hydrochloric acid to give a white precipitate, not realising that all ammonium salts are soluble. Thus no precipitate would be formed for this reaction.

Part (b) (i): Many candidates knew the catalyst for the Haber process. Fe^{2+}/Fe^{3+} or Fe_2O_3 were not accepted for finely divided iron. Infrequently, V_2O_5 was mentioned. It should be noted that even though heat was mentioned, it was not a catalyst.

Part (b) (ii): It was evident that numerous candidates were unfamiliar with the importance of using a high pressure in the Haber process. Candidates were required to state that the reaction involved gases; that molecules come closer together; that there is a reduction in volume; there is frequent collisions; that the reaction occurs with a reduction in the number of molecules (from reactants to product); that a high pressure will favour the forward reaction/increase the yield of ammonia, and that the rate of reaction will be faster.

Part (b) (iii): Few candidates were able to gain the three marks for naming the reactants/products on the diagram, labelling axes of the energy profile diagram, and showing an exothermic change on an energy profile diagram. Notwithstanding, the mention of the reactants (hydrogen and nitrogen) and product (ammonia) in the question, many candidates did not write them on energy profile diagram. In many instances, when written, the diatomic nature of hydrogen and nitrogen was omitted (N instead of N_2 and H instead of H_2). Energy profile diagrams varied in structure from unlabelled axes, no axes, and even a representation of an endothermic change. Some candidates even drew elaborate flow diagrams and diagrams of the industrial preparation of ammonia to represent energy profile diagrams. In conclusion, this question was poorly answered, with over 50% of the candidates gaining three or less marks.

Paper 03 - Extended Essay

Question 1.

This question was the least popular of the six questions in this paper but it elicited some very good answers. Candidates were required to:

- Prepare a dry sample of calcium nitrate
- Deduce a method of determining if the prepared salt was free of calcium carbonate
- Write chemical equations for the effect of heat on nitrates
- Chromium plate an iron rod, giving electrode equations and a circuit diagram and
- Perform simple calculations to determine the mass of substance produced during electrolysis.

In Part (a) (i), many candidates seemed to think that calcium carbonate was soluble and measured out specific volumes of it to be mixed with nitric acid. Others used a titration process. The general description expected was to add the calcium carbonate to the acid until it was in excess, filter off the excess, evaporate the filtrate to concentrate it and cool the resulting solution to cause crystallisation. Some candidates used excess nitric acid, a procedure sometimes employed at university level, but failed to evaporate the solution using a water bath, a critical step since the solution produced is very acidic. A large percentage of the candidate population failed to perform the last step which was to filter off the crystals and dry them.

Common mistakes in Part (a) (ii) included:

- Adding the salt to limewater and
- Adding aqueous barium chloride to the salt.

What was required was a test and the outcome. Many candidates added the salt to water but failed to indicate that a white solid would be observed if calcium carbonate was present. Instead, they simply stated that the salt would be insoluble.

Another popular answer was to heat the salt. It should be pointed out to students that if a mixture of a carbonate and a nitrate is heated, nitrogen dioxide as well as carbon dioxide would be evolved so that testing the emitted gas(es) with limewater would not be at all useful. The examiners expected that candidates would add acid and test the gas evolved with limewater.

Equations for the effect of heat on calcium and sodium nitrate in Part (a) (iii) were generally well done. Marks were lost mainly in balancing the equations.

Part (b) (i) was poorly answered. There were several problems with the circuit diagram. Firstly, a high number of candidates did not seem to know that the long stroke in a battery represents the positive pole and labelled the attached electrode as the “iron cathode”. Secondly, the electrodes were often not connected to a source of electricity but were simply two rods immersed in the electrolyte. Thirdly, candidates used either a carbon anode instead of chromium or simply labelled “anode” without stating what it was made of. Most candidates, however, recognized that the object to be plated, namely the iron rod, should be made the cathode. In explaining the electrolysis, many candidates indicated that OH^- would be discharged at the anode and gave equations that resulted in the formation of water and oxygen. Also, where they recognized that chromium ions would go into solution as ions, the charge on the ion was often given as 2+ instead of 3+ and the state symbols were often omitted. Teachers must emphasise the need for state symbols when ionic equations are written.

The calculation in (b) (ii) was quite well done. The main errors were the use of the relative atomic mass of chromium as 25 instead of 52 and the omission of the 3:1 mole ratio of electrons to chromium. Many candidates used a 1:1 ratio.

Question 2.

This was the most popular question on the paper. It tested candidates' knowledge of the particulate nature of matter. Part (a) of the question revolved around three experiments that were set up:

- Experiment 1 was the familiar diffusion experiment with ammonia and hydrogen chloride
- Experiment 2 illustrated diffusion of $KMnO_4$ in a beaker of water and
- Experiment 3 demonstrated osmosis in paw-paw strips placed in a beaker of water.

Candidates were required to describe what would be **observed** in the experiments, to account for their observations and suggest how the rate of change of observations in Experiment 2 could be increased. Part (b) tested their knowledge of chromatography.

As in previous years, candidates continue to demonstrate their lack of understanding of the term 'observation' and gave vague and often imprecise descriptions of what they would observe. For example, instead of describing the ammonium chloride formed in Experiment 1 as a white solid ring, many simply wrote that a 'cloud', a 'fog' or a 'smoke' would be observed. In Experiment 2 the permanganate was described as "dissolving in water until the entire solution turned purple". Some candidates confused the colour of the permanganate with that of dichromate whilst others just stated that the "permanganate crystals spread out in the water" without any reference to its colour. It was expected that candidates would observe the spreading of the purple colour of the permanganate from the bottom throughout the solution until the entire solution became a uniform colour. In Experiment 3 explanations rather than observations were generally given. Many candidates wrote about the paw-paw strips absorbing water as water moved from a region of higher concentration to one of lower concentration.

The candidates recognized that the processes occurring in Experiment 1 was diffusion and in Experiment 3 was osmosis. Many, however, referred to the process in Experiment 2 as either dissolving or Brownian Motion.

Some candidates confused the nature of matter with the states of matter and offered explanations that revolved around the permanganate and the paw-paw strips being solids, the water being a liquid and the ammonia and hydrogen chloride being gases. It was expected that candidates would explain that matter is made up of particles that are in a state of constant motion and move from a region of higher concentration to one of lower concentration. None of the candidates offered any real explanation of how matter is transported in the experiments, although a few mentioned that the medium in Experiment 1 was air and in the other two experiments it was water. They were expected to explain that the molecules in the transport media were also in constant motion and would collide with the ammonia and other particles thus pushing them along.

Part (a) (iii) garnered a variety of responses for increasing the rate of observation in Experiment 2. Candidates listed all the factors that affect the rate of reaction including using a catalyst, increasing the surface area by crushing the permanganate and increasing the amount of permanganate used. A creditable number used heat and explained that this would increase the kinetic energy of the particles causing them to move faster.

In Part (b) (i), candidates did not know that the advantage of using chromatography lies in the fact that only small amounts of the mixture are needed, that the components are not destroyed by the process or that it can be used to separate mixtures of substances with similar properties. Instead many of them focused on it being cheap and accurate. Neither of these responses was credited.

In Part (b) (ii), candidates lost marks for not labelling the starting line and the solvent front in their chromatograms. Most recognized that the pure substance would produce only one spot whilst the mixture would produce more than one. Teachers must instruct their students on the difference between a chromatogram, the actual product, and the process of chromatography as many candidates attempted to show the entire process in diagram form.

Question 3.

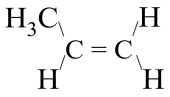
This question was slightly more popular than its counterpart in Section B. It tested candidates'

- Knowledge of the reactions of carboxylic acids
- Ability to write equations for these reactions
- Use of knowledge of bromination of alkanes and alkenes
- Knowledge of the conversion of alkenes to alcohols and polymers.

In Part (a), many candidates were able to write correct well balanced equations for the stated reactions. The main errors encountered in Part (i) were the use of Na^+ instead of Na for sodium and the formation of water rather than hydrogen gas as a product of the reaction between hexanoic acid and sodium. In Part (ii), candidates had difficulty balancing the equation for the reaction between the acid and ethanol. Many also gave incorrect formulae such as $C_2H_5COOC_6H_{11}$ and $C_6H_{11}COOHC_2H_5$ for the ester. Additionally, quite a few candidates omitted the water from the products of the reaction.

In Part (b), the reaction between bromine and hexane was consistently referred to as either 'replacement' or 'displacement' rather than the accepted 'substitution' reaction. Also, the candidates often erroneously determined that the bubbles of gas seen to be escaping from the mixture was hydrogen rather than HBr. Another common mistake was to refer to the dense fumes formed with ammonia as ammonium chloride rather than the bromide. The equation, however, was generally well written and most candidates obtained the two marks awarded. In (b) (iii) candidates were familiar with the decolorisation of the bromine by hexane and correctly identified the reaction as an addition.

Few of the candidates recognized that the partial structure of the polymer in Part (c) should have a methyl branch and gave straight chained structure with nine carbon atoms. Teachers should try to encourage their students to write the structure of alkenes in the form:



rather than $CH_3 \cdot CH= CH_2$

especially when discussing the topic of polymerization so that they would more readily recognize what happens when molecules join on to each other. A majority of the candidates wrote good equations for the conversion of propene to propanol and the conditions for the reaction were well known. In Part (iii), candidates knew that the separation of the alcohol from the alkene required some form of distillation. Some drew diagrams representing simple distillation when what was required was a diagram showing fractional distillation. The diagrams were generally scrappy and were not properly labelled. In particular the condenser must be labelled with the water inlets and outlets and this was often mixed up or omitted.

Question 4.

This seemed to be the most challenging question on the paper for the candidates who misinterpreted what was being asked and gave answers that were unrelated to the question. Most candidates performed poorly.

The question tested candidates' understanding of

- reduction processes used in the extraction of metals
- the relationship between the choice of extraction method employed and the position of a metal in the reactivity series
- separation methods
- factors affecting products of electrolysis and
- acidic and basic oxides.

In Part (a), many candidates were able to name a metal high in the reactivity series and one that was lower and give corresponding processes for their extraction, namely electrolysis and reduction with coke/carbon monoxide respectively. However, these candidates failed to link the position in the reactivity series with the relative reactivity of the metal or the stability of the ore. A point for teachers to note is that stating that aluminium is higher in the reactivity series than copper does not necessarily mean that aluminium is high in the series and copper is low in the series. Furthermore, they did not refer to the strength of the reduction process that was needed. As a result, the majority of candidates did not get more than two of the five marks allotted for this part of the question.

In Part (b), it was obvious that most candidates did not read the question carefully or did not realize that the ore from which the two metals were to be extracted was a **MIXTURE** of the two oxides and therefore the oxides had to be first separated from each other. From the information given, it was expected that the candidates would first add sodium hydroxide to the ore and then filter the resulting mixture. This would leave the oxide of metal B as the residue whilst the oxide of metal A would dissolve and form the filtrate which could then be heated to dryness and consequently melted. The molten mixture could then be electrolysed and the metal A would be obtained at the cathode. The oxide of metal B which remained on the filter paper could be heated with coke or in a stream of carbon monoxide to obtain the metal. Most candidates identified metal A as aluminium and B as iron and proceeded to give very detailed accounts of the extraction of these two metals. Since this was not what was required of the question these candidates scored poorly. Teachers must emphasise to their students the importance of reading questions carefully and answering what is asked and not what one expects the question to ask.

Part (c) tested whether candidates understood why metals high in the reactivity series are obtained by electrolysis of the molten rather than the aqueous salt. Candidates exhibited a general lack of understanding of this area of the syllabus. Many candidates did not seem to understand the term 'molten' and consistently referred to the molten salt as being "concentrated". Few gave the ions present in each of the electrolytes and therefore could not explain that since the aqueous salt provided both H^+ and X^+ ions at the cathode, because hydrogen is lower in the reactivity series than X, it would be preferentially discharged. Since the molten salt contained only the one cation, X^+, X would be deposited at the cathode. Explanations often involved the preferential discharge of OH ions.

In Part (d), most candidates did not refer to the acid/base nature of the reaction between sulphur dioxide and calcium oxide as the basis for the removal of the gas from the atmosphere. Many wrote about the environmental effects of sulphur dioxide. Additionally, candidates did not recognize that salts of sulphur dioxide are sulphites and not sulphates and that SO_2 would thus have to be first oxidized by the oxygen in the air to SO_3. Thus the following incorrect equation was often given as $CaO(s) + SO_2(g) \rightarrow CaSO_4(s)$.

Question 5.

This question tested the concepts and principles in two units of the C Section of the syllabus. Since candidates were required to prepare for only one of the options in Section C2 namely Option 3 OR 4, the Council regrets the error in this question and has made every effort to ensure that candidates were not penalized in any way. Answers in this question were of a slightly higher standard than in the alternative.

In Part (a), candidates were required to discuss **TWO** physical properties of water as they related to processes occurring in living systems. **TWO** errors were predominant. Firstly, candidates ignored the instruction to relate the property to living systems, and concentrated on the relationship to the abiotic environment. For example, the presence of dissolved oxygen in an aquatic environment was not related to the process of respiration in fishes. Secondly, candidates did not identify the unique nature of water by stating whether the specific heat capacity was high or the volatility low. Rather, candidates simply stated that "because of the heat capacity of water, it helps to maintain body temperature".

In Part (b) (i), definitions of "hard water" were often incomplete. For example, it was often stated that 'hard water does not lather well' with no reference to soap being made. Also, definitions referred to water containing dissolved calcium (Ca) and magnesium(Mg) rather than their IONS (Ca^{2+} and Mg^{2+}). In Part (b) (ii), the formula for calcium hydrogen carbonate was often incorrectly given as $CaH(CO_3)_2$ or $CaHCO_3$. Some candidates believed that any hydrogen carbonate would produce temporary hardness and even gave the formula for sodium hydrogen carbonate. The importance of the calcium and magnesium ions in causing permanent hardness was also unknown to many who believed that it was the sulphate ion that was responsible.

Very few candidates gained full marks for the two equations showing the removal of permanent hardness by sodium carbonate and temporary hardness by boiling. The most common error in the first equation was the incorrect formula for sodium carbonate which was often given as $NaCO_3$. Additionally, the absence of state symbols indicated a general lack of knowledge of the principle of precipitation for the removal of permanent hardness in water. Teachers please note that it is imperative that students write state symbols for this equation. It is a good practice to encourage them to write **ALL** equations using state symbols. In the second equation, many candidates believed that the hydrogen carbonate would decompose to the metal oxide or even the metal.

The term "compare" as given in the glossary in the syllabus requires a statement about similarities and/or differences. Thus, if candidates are asked to "compare the differences between soaps and soapless detergents on hard water" it is expected that **BOTH** substances must be discussed. Candidates often gave the effect of only one. For example, a popular answer was that soaps form a scum with hard water with no reference being made about the effect of the soapless detergent. This was the only effect that was well known by most candidates. They were expected to discuss also the cleansing action and solubilities of the calcium and magnesium salts of the two detergents.

<u>Question 6.</u>

This question tested candidates' knowledge and understanding of the

- components of toothpaste
- action of the components of toothpaste
- advantages and disadvantages of chemical and biological pest control.

In Part (a) (i), many candidates believed that the important components of toothpaste were calcium and fluorine instead of abrasives such as calcium carbonate, fluorides, detergents and glycerol.

In (a) (ii), candidates were asked to describe, with the aid of an equation, how one component of toothpaste could strengthen the enamel of teeth. It was expected that the candidates would use the formula given for tooth enamel to write the equation:

$$Ca_{10}(PO_4)_6(OH)_2 + 2F^- \rightarrow Ca_{10}(PO_4)_6F_2 + 2OH^-$$

Many candidates wrote the formula of fluorine as Fl. Others failed to realize that it was the fluorine that was responsible for strengthening the tooth, and not the calcium from the calcium carbonate. Candidates did not recognize that the replacement of the hydroxide by the fluorine was what caused the enamel to become stronger.

In (a) (iii), the majority of candidates could not explain what happens in tooth decay. They failed to appreciate that the bacteria in the plaque converted carbohydrates to acid which reacted with the enamel causing it to erode and become susceptible to bacterial infection. Many candidates knew that acid was somehow involved in the process but some thought that the acid was hydrochloric acid and others believed that the bacteria gave off the acid. A simple ionic equation showing the reaction between hydrogen and hydroxide ions was also expected to illustrate the process. Many candidates attempted complex equations involving the formula given for tooth enamel and got into difficulty.

In Part (b), the candidates were more familiar with advantages and disadvantages of chemical control than they were with biological control of pests. One misconception that was repeatedly noted was that candidates believed that chemical control was more expensive than biological control.

Paper 04 – School-Based Assessment (SBA)

General Comments

The improvement in the quality of the laboratory books and mark schemes submitted for moderation are two of the factors which made the moderation exercise a much easier process than in previous years. Teachers are commended for the efforts that have been made to conduct more than the recommended minimum number of practicals and also for engaging students in a wide range of practical activities.

While there was some improvement in the quality of the mark schemes generally, there still continues to be a problem with some of the criteria for assessing ORR and AI as well as the types of tasks suitable for Planning and Design. In addition, at least 28 centres submitted no mark schemes.

There was slight improvement in the quality of the books from some of the newer centres. However, many of these teachers are still not clear on the standard of practical activities that is required for the SBA. In a number of cases, one practical activity is being used to assess more than two skills. In addition to paying careful attention to the moderation feedback report, teachers with limited experience in conducting SBA are encouraged to read the relevant section of the syllabus and collaborate with more experienced members of staff from some of the more traditional Centres for tips on conducting the SBA. Teachers at a given Centre are encouraged to work together in planning for and selecting practical activities. Where possible, it may also be useful for teachers from the science department to engage in small-scale moderation exercises at their schools so as to evaluate mark schemes and the suitability of practical activities. This should also help to improve the consistency with which mark schemes are used.

A significant amount of time is spent doing laboratory practical exercises on “separation of mixtures” with some Centres doing as much as five different activities. This tends to leave very little time for conducting exercises on some of the more difficult concepts and limits the possibility of covering the remaining aspects of the syllabus through practical work. Some essential activities continue to be neglected or treated in a somewhat trivial manner, requiring very little critical thinking on the part of the students. These include making deductions from qualitative analysis, writing balanced molecular and ionic equations and activities related to electrolysis, heating substances, organic chemistry and redox reactions.

In a few cases, the practical activities done are not based on the chemistry syllabus. For example in number of instances, students were asked to plan and design activities to show that light or some other variable is necessary for photosynthesis and to make detailed drawings of the procedure for conducting an experiment.

One other disturbing trend is that some teachers are only correcting the practical exercises done for the SBA and leaving the others unmarked. In a few instances, enough care was not given to correcting students’ work, as information that was incorrect was marked correct by teachers.

Some of the specific problems encountered at moderation are outlined below.

1. Assessment of Planning and Design Skill:

    a. The unsuitability of some activities for assessing Planning and Design as well as uncertainty about what is expected by “treatment of results” are the most common problems associated with the assessment of this skill. Teachers should note the specific description of the learning outcomes being tested by this skill as stated in the syllabus (Appendix 2 point 3). Standard activities that require the straight recall or reproduction of information that is available in any chemistry text book are not suitable for assessing planning and design. A sample of such unsuitable activities selected from the candidates’ books is listed here.

        i. Design an activity to test the hardness of water.

        ii. Plan and design an activity to show the conditions necessary for rusting

        iii. Plan and design an activity to prepare magnesium sulphate

        iv. Plan and design an activity to show that the rate of reaction of calcium carbonate with dilute hydrochloric acid is dependent on surface area.

        v. Plan an activity to determine the heat of combustion of ethanol

Suitable PD activities should pose a problem for students to solve using concepts from the syllabus being tested. The use of the concepts should be in some sort of "novel" context. As such, these activities should not be a repeat of activities done previously or readily available from a text but should require the application of knowledge. Some of the concepts tested by the activities in (i) to (v) above can be made into more appropriate PD activities as outlined below. These examples are also taken from samples of work submitted.

i. Design a suitable activity to compare the hardness of water from two water sites.

ii. Plan and design an activity to determine whether the temperature of salt water affects the rate at which iron rusts.

iii. Crushed celery was placed in a sealed bag containing H_2O_2 and left in a closed cupboard along with a similar bag containing only H_2O_2. After few hours, the first bag became much more distended than the second bag.

iv. Alcohols are useful fuels whose energy values are linked to the molecular weight. Design an experiment that would allow you to establish the relationship between molecular weight and heat of combustion for the alcohols ethanol, propanol and butanol.

v. "Blast Off", "Super" and "Everlasting" are three different brands of baking powder. Martha insists on using Blast Off because she claims it is most effective. Plan and design an experiment to determine if Martha's belief is true.

b. In a number of cases, candidates lost marks for the PD activities because they presented actual results of data, suggesting that the activities were carried out. Teachers are reminded that PD activities are not to be conducted. The "Expected Results" should indicate the data **to be collected**. For example, the activity comparing the two brands of baking powder in (v) above, might require the collection of carbon dioxide gas in a syringe. In the "Expected Results" students could therefore present a table with Type of Baking Powder and Volume of Carbon Dioxide as the headings. However, no figures should be recorded in the Table.

c. The "Treatment of Results" should be linked to the aim which should be linked to the hypothesis of the experiment. Using the same example of the baking powder, students might be expected to state that one brand of baking powder would produce a larger volume of carbon dioxide in a fixed time period than the others.

d. At least four PD laboratory exercises should be done over the two year period. In many instances students did fewer, resulting in reduction of their marks for PD.

e. Exercises used to assess the PD should not be used to assess any other skill.

2. Assessing the Analysis and Interpretation Skill

Assessment of this skill is affected by:

- confusion of criteria suitable for ORR with those suitable for AI
- inadequate number of criteria for assessing AI in a particular practical; in some cases, one or two questions were used to assess AI which did not prove to be suitably challenging for the students
- using questions to assess AI which bear no relation to the data collected
- selecting inappropriate activities for assessing AI.

The result is that AI is not being properly assessed and candidates' grades do not accurately reflect their conceptual understanding based on the general quality revealed in the laboratory activities presented.

i. Equations and discussions and explanations should be assessed as A/I and not ORR. Teachers should pay closer attention to the writing of equations and are encouraged to correct inaccurate equations in students' books. State symbols are required for ionic equations.

ii. The actual plotting of the graph should be assessed under ORR but calculations and interpretation of data using the graph should be treated as A/I.

iii. For qualitative analysis, marks awarded for inference should be linked to the observations made. Also qualitative analysis exercises that require students to conduct tests on known reagents are not suitable for assessing A/I. Rather, students should be given unknowns when testing for A/I. In conducting qualitative analyses, students should be encouraged to complete their results in tabular form.

iv. Attempts should be made to include at least one activity that requires calculations (with several steps), such as enthalpy changes, concentration, the mass of product obtained during electrolysis for assessment of AI. Calculation of concentration from volumetric analysis should be done from first principles and should not involve using: MaVa = MbVb.

v. Other activities suitable for assessing AI include reactions of acids with various substances that require inferences to be deduced, energetics, rates of reaction which requires explanation for the shape of various parts of the graph and deductions from the graph.

vi. Definitions and drawing of models of crystal structure and bonding diagrams are not suitable AI activities

vii. Greater attention should be given to writing the correct formulae and equations. In many instances these were marked correct when there were errors in the candidates' work.

3. Table of Contents

i. This continues to be a sore point in many books presented for moderation. All activities should be dated and pages numbered.

ii. Activities in the laboratory books should have the same titles or numbers as those in the teachers' mark scheme.

iii. The activities being used to compute the students' SBA scores for the various skills should be clearly indicated in the students' notebooks and mark scheme.

4. Absence of or Inappropriate Mark Schemes

i. Moderation is made difficult if mark schemes are inappropriate or unclear. Incomplete or unsatisfactory mark schemes will undoubtedly work to the students' disadvantage, as an alternative mark scheme has to be used. As indicated in last year's school report, some teachers are allocating very few marks for the AI activities. In many instances the total possible score for AI is 4 or 5 marks. Ideally, the mark for each skill should be at least 10. Careful selection of activities to facilitate more discussion of the data or response to questions should reduce this tendency.

ii. This year saw an increase in the number of Centres that did not send any mark schemes for the sample of books submitted. Where this happens candidates may be penalized as mark schemes have to be created in order to moderate the books. Where a teacher is teaching in two Centres and submits two sets of books but intends the mark scheme to be used for both sets of books, this should be clearly indicated on the moderation sheet.

iii. In a few instances teachers submitted general mark schemes for all the skills. This practice should be discontinued and teachers should submit specific mark schemes for each activity.

5. Re-sit Candidates / Extenuating Circumstances

Teachers are again reminded to pay attention to the syllabus guidelines (page7) for re-sit candidates. If books of re-sit candidates are submitted for moderation then these should be clearly identified. Where circumstances such as illness or absence of staff have resulted in some adjustments to the required number of activities and the times where assessment takes place, this should be outlined in writing to the Registrar so that candidates are not penalized unnecessarily.