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

REPORT ON CANDIDATES' WORK IN THE SECONDARY EDUCATION CERTIFICATE EXAMINATION MAY/JUNE 2009

CHEMISTRY

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GENERAL PROFICIENCY EXAMINATION

MAY/JUNE 2009

GENERAL COMMENTS

Candidates were required to write three papers – Paper 01, comprising 60 multiple choice items. Paper 02, essay-type questions and Paper 03, the School-Based Assessment.

On Paper 02, candidates were required to complete six questions, five of which were compulsory and the sixth selected from one of two questions from Section C of the syllabus. Questions 1 – 3 were structured items, while 4 – 7 were extended essay items.

The contributions of the papers to the overall examination were as follows:

Paper 01 - (Multiple Choice)	- 30%
Paper 02 - (Structured Essay)	- 50%
Paper 03 - (School-Based Assessment)	- 20%

The candidates' performance at this sitting of the examination showed some improvements over performance in previous years. The optional question on Gardening (Question 7, Paper 02) was generally well done by those candidates who selected it. Many candidates also performed well on Part (a) of the data analysis (Question 1, Paper 02) which tested knowledge of the mole and drawing and interpreting graphs, and on Question 4 which was based on the Periodic Table. However, several issues highlighted in previous reports continue to cause concern and it does not appear that there is any improvement in these areas. These areas include the performance on items that test organic chemistry, particularly polymers and knowledge of the definitions of key concepts in chemistry. The many vague responses reflect a superficial understanding of some very important concepts.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the profile, Knowledge and Comprehension. Performance on this paper continued to be steady and satisfactory. The marks ranged from 0 to 59.

The mean score earned by candidates was 60 per cent with a standard deviation of 11.

Paper 02 – Structured Essay

NOTE: THESE COMMENTS SHOULD BE READ IN CONJUNCTION WITH THE QUESTION PAPER AND SYLLABUS IN ORDER TO DERIVE THEIR FULL BENEFIT.

Question 1

Syllabus References: A8.1, 6.5, 6.8, 3.3; B2, 4.1, 4.2, 7.1, 7.2, 7.3

Part (a)

Candidates' Performance

Part (a) was fairly well done with an average mark of 9.8 (61 per cent) out of 16, with approximately 74 per cent of the responses obtaining a mark of 8 or more.

Parts (a)(i) a) and b)

These parts tested candidates' knowledge of the (metal) reactivity series, specifically the relative reactivity of zinc and copper.

Candidates' Performance

Most candidates were able to give two observations that would result from the reaction between aqueous copper(II) sulphate and zinc powder.

Common Incorrect Responses

- Black precipitate of copper.
- Blue precipitate of solid copper.
- There would be a colour change.

Expected Responses

- Blue colour of copper(II) sulphate fading to a lighter blue or to colourless.
- Formation of a red-brown solid (copper metal).
- Increase in temperature.

It was noted, however, that some candidates used terms like 'white solution' and 'clear solution' for colourless, and erroneously gave the appearance of the solid copper as a blue solid, particularly mistaking Cu(s) for Cu^{2+}(aq).

Part (a)(i) c)

Candidates were required to distinguish between an 'exothermic reaction' and an 'endothermic reaction'.

Candidates' Performance

Many candidates had difficulty in distinguishing between these two types of reactions. Candidates were expected to give differences based on the net absorption/release of energy (heat).

Common Incorrect Responses

- Endothermic reactions are slow, exothermic reactions are fast.
- Endothermic reactions are inside, exothermic reactions are outside.
- Endothermic reactions are a positive charge, exothermic reactions are a negative charge.
- Exothermic reactions give out energy while endothermic reactions require energy.

Expected Responses

Endothermic reactions occur with a net absorption of energy from the environment (and this results in a decrease in the temperature) while exothermic reactions occur with a net release of energy into the environment (which results in an increase in temperature).

Part (a)(ii) a)

This section involved the assessment of the Use of Knowledge (UK) and Experimental Skills (XS) profiles. Candidates were required to make temperature readings from five displayed thermometer diagrams and compute the changes in temperature.

Candidates' Performance

This was generally well done, with most candidates scoring full marks.

Part (a)(ii) b)

This section required the candidates to plot the temperature changes against the mass of zinc added.

Candidates' Performance

Although the points were plotted correctly in most cases, several candidates had difficulty in drawing a smooth curve through the points. In some cases, candidates used a ruler to connect the points by straight lines.

Part (a)(ii) c)

This part required the use of the candidates' interpolating skills, to determine the temperature change for a specified mass of zinc.

Candidates' Performance

Most candidates were able to interpolate correctly and obtained the one mark available for UK.

Part (a)(iii)

Candidates were required to calculate the mass of zinc required to completely react with 100 cm^3 of 0.20 mol dm^{-3} copper(II) sulphate.

Candidates' Performance

Many candidates failed to gain the maximum two marks available for UK, because of their inability to calculate the number of moles present in a given volume of solution of known concentration.

Common Incorrect Responses

- Many candidates incorrectly assumed that 100 cm^3 of a 0.20 mol dm^{-3} solution contained 0.20 moles, instead of 0.2 x 100/1000 = 0.02 moles

Expected Responses

A 0.20 mol dm^{-3} solution is one that contains 0.20 moles of solute per 1 dm^3 (or 1000 cm^3) of solution, hence:

1000 cm^3 of 0.20 mol dm^3 copper(II) sulphate contains 0.20 moles
1 cm^3 of 0.20 mol dm^3 copper(II) sulphate contains (0.20/1000) moles
100 cm^3 of 0.20 mol dm^3 copper(II) sulphate contains 100 x (0.20/1000) = 0.02 moles.
Cu^{2+}(aq) and Zn(s) react in a 1:1 mole ratio, therefore 0.02 moles of zinc are required.
Mass = number of moles x Relative Atomic Mass (RAM) = 0.02 moles x 65 g mol^{-1} = 1.3 g

Part (a)(iv)

Candidates were required to use the information from Part (iii), to explain why the different masses of zinc in the last two experiments gave the same change in temperature.

Candidates' Performance

This part was generally well done. Some candidates seemed not to realize, however, that from the type of graph drawn, the horizontal portion at the end indicates the completion of the reaction.

Common Incorrect Responses

- The small change in mass of zinc would not cause a difference in temperature.

Expected Responses

The 100 cm^3 of copper(II) sulphate solution requires 1.3 g of zinc for complete reaction. Experiments 4 and 5 have masses that are in excess of this mass. After the 1.3 g of zinc have reacted, the reaction would be complete.

Part (a)(v)

Candidates were required to account for the observation that when silver is used instead of zinc, no temperature change is observed.

Candidates' Performance

Many candidates compared the reactivity of silver to zinc, instead of the reactivity of silver to copper, or did not give a detailed enough comparison.

Common Incorrect Responses

- Silver is less reactive.
- Silver is less reactive than zinc.

Expected Responses

Silver is below copper in the reactivity series, therefore silver would not displace copper(II) ions from solution.

Part (b)

In Part (b), candidates were given the results of three tests on Solid R. They were required to indicate the possible inferences from the results of the tests and to deduce the identity of Solid R. The presence of the ammonium ion and ammonia as the pungent gas which turned red litmus blue were the inferences for Test 1. Test 2 was a positive test for the chloride ion and an ionic equation was required for the formation of silver chloride from silver and chloride ions. Solid R should have been identified as ammonium chloride.

Candidates' Performance

In spite of the simple and well-known tests for the ammonium and chloride ions, candidates performed poorly on the qualitative analysis question. Very few were able to score more than two (40 per cent) of the five marks for this section. The responses suggested that candidates lacked experience with these "routine" qualitative tests. Some of the responses were quite far-fetched such as Zn^{2+} and NO_3^-.

Common Incorrect Responses

- Many incorrect responses were given for the formula of the ammonium ion and ammonia gas.
- Several candidates referred to ammonia as ammonium gas.
- Far too many candidates are still unable to write ionic equations as they do not know the symbols for the ions.

Part (c)

Part (c) tested candidates' planning and designing skills. They were required to plan a suitable method for distinguishing between vinegar and muriatic (hydrochloric) acid.

Candidates' Performance

While most candidates were able to score one mark for correctly listing the materials required for the method suggested, many were unable to identify suitable methods. Many candidates focused their responses on the "cleaning abilities" of the cleaners rather than the properties of ethanoic and hydrochloric acid. Several candidates repeated the smell of the cleaners as stated in the question or outlined methods for cleaning kettles, tiles and toilets as a means of differentiating between the two acids. Full marks were awarded for feasible procedures that included all important steps that were logically organized. Candidates used a range of possible responses which were accepted. These included:

- The reaction of the vapour from the acid with ammonia to produce ammonium chloride.
- Universal indicator – comparing colours and /or pH values.
- pH meter – comparing pH values.
- Testing for chloride ions.
- Titrating – comparing the volume of acid/base used for neutralization.
- Formation of the ester in the case of the vinegar.
- Reaction with metal, metal carbonate, metal hydrogen carbonate – comparing the rate of reaction or the volume of gas evolved in a specific time.
- Electrolysis – comparing ammeter readings with each acid as the electrolyte.

As well as suggesting a suitable method, candidates were required to indicate the basis on which the two acids could be distinguished given the method selected. Those who selected suitable methods were usually awarded marks in this section.

Common Incorrect Responses

- The use of litmus paper to differentiate the acids was most common. Many candidates thought that the stronger acid would turn the litmus a darker shade of red than the weak acid.
- Failure to recognize the need to carry out the same tests on both acids in order to compare results.
- Carrying out different tests on each acid.
- Some confusion concerning the correct name of the universal indicator paper. Names such as pH scale and universal litmus paper were used.

Question 2

Syllabus References: A1.2, 4.6, 4.7; B1: 1.7, 1.8, 1.9, 3.1

This question tested knowledge of inorganic and organic chemistry. Most candidates did fairly well and were able to score more than 8 (53.3 per cent) of the 15 marks allotted.

For Part (a), candidates were presented with a diagram of the effect of temperature changes on ice. They were required to identify the states of matter, read from the graph the melting and boiling points, deduce what would be observed during melting and to state the processes for converting water vapour to water and solid iodine to gaseous iodine.

Part (b) tested knowledge of allotropes of carbon and Part (c), knowledge of hydrocarbons and structural isomerism.

Candidates' Performance

Part (a)

Candidates did very well on this part although the weaker candidates were unable to name sublimation as the process occurring when solid iodine was converted to gaseous iodine. Almost all candidates were able to give the names of the three states of matter and to identify the temperatures which represented melting and boiling points from the diagram showing the change of state with temperature. The better candidates were able to clearly state that point C would have a mixture of both ice and water. Responses such as "the ice has melted" were not awarded any marks.

Part (b)

Far too many candidates lost marks because they were unable to give a clear definition of allotropes. Here, they confused many concepts such as isotopes and isomers with allotropes. Additionally, they described allotropes as compounds instead of elements.
The majority of candidates were able to identify graphite as the allotrope of carbon that conducts electricity but only a few were able to explain why.

Part (c)

While many candidates listed crude oil, petroleum and natural gas as sources of hydrocarbons, which were all awarded full marks, a wide variety of incorrect responses were also given. Most candidates gave a correct definition for structural isomerism but again used terms such as atoms and elements quite loosely and incorrectly in the definition. For the most part, candidates were able to draw a four-carbon hydrocarbon. However, many were challenged to draw the corresponding isomer.

Common Vague or Incomplete Responses

- Identification of the process taking place at point C, melting, instead of stating what would be observed.
- Classification of allotropes as atoms and compounds.
- Attributing the conductivity of graphite to ions present in the element or identifying it as a metal with a “sea of mobile electrons”.
- Identification of the corresponding isomer of an alkane as an alkene.
- Bending the hydrocarbon chain to form a new isomer instead of rearranging the carbon skeleton.

Question 3

Syllabus References: B1: 3.2, 3.1, 2.7, 4.6, 3.8; A1: 5.4

This question was very poorly done, with an average mark of 4 (26.7 per cent) out of 15. Only 20 per cent of the candidates were able to obtain a score of 8 (53.3 per cent) or more out of the 15 marks, while 3 per cent of candidates scored between 13 and 15. Approximately two-thirds of the candidates earned less than 5 (33.3 per cent) marks or did not respond. In this question, candidates were required to identify and give uses for the lightest and heaviest fractions in the fractional distillation of crude oil; draw the structure of products when bromine and sodium reacted with a given molecule (with alcohol and alkene moieties), draw the partial structure of a polymer, draw the structure of a monomer given the polymer, and identify differences in the enzyme hydrolysis and acid hydrolysis of polyamides.

Part (a)

In this part, candidates were required to (i) name the property of compounds upon which fractional distillation is based, (ii) name the lightest and heaviest fractions obtained from fractional distillation of crude oil, and (iii) state one use of each of the named fractions.

Candidates’ Performance

The majority of candidates correctly indicated that the property was the boiling point. Many did not know the names for the lightest and heaviest fractions, while most candidates were able to give a correct use of either one or both fractions.

Common Incorrect Responses

- Names of lightest fraction: liquified gas, natural gas.
- Use of lightest fraction: fuel for cars.
- Use of heaviest fraction: fuel.

Expected Responses

(i) The boiling point is the property of compounds upon which fractional distillation is based. Vapour pressure is also accepted.

(ii) The names and uses of the crude oil fractions:

Lightest fraction:

Name – gaseous fraction/propane/methane

Use – cooking gas/source of hydrogen

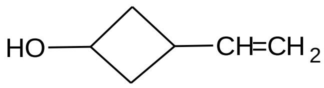
Heaviest fraction:

Name – bitumen

Use – road paving

Part (b)(i)

Candidates were required to draw the products of the reaction of a molecule bearing –OH and $–CH=CH_2$, functionalities:



Candidates' Performance

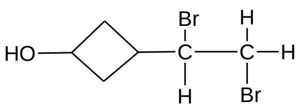
The majority of the candidates did not correctly indicate the addition of bromine across the double bond, or the reaction of sodium with the –OH group.

Common Incorrect Responses

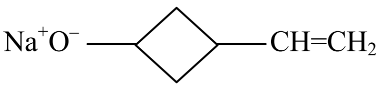
- Bromine reacting with –OH group.
- Addition of bromine, with retention of double bond.
- Addition of sodium across double bond.
- Opening of the ring on reaction with bromine.

Expected Responses

Bromine (Br_2) adds across the double bond to give:



Sodium (Na) reacts with the –OH group to liberate hydrogen gas and forms the alkoxide salt,



Part (b)(ii)

Candidates were required to draw the partial structure (using three molecules of A) of the polymer formed from the polymerisation of A.

Candidates' Performance

A large number of candidates produced a partially correct structure and were able to get one of the two available marks, but most had the structure incorrectly drawn.

Common Incorrect Responses

- Linking of the rings.

Expected Responses

The expected structure should have a 'backbone' of carbon-carbon bonds with the side groups on alternating carbon atoms:

$$\begin{array}{ccccccccccccc} & & & X & & & & X & & & & X & \\ & & & | & & & & | & & & & | & \\ — & CH_2 & — & CH & — & CH_2 & — & CH & — & CH_2 & — & CH & — \end{array}$$

Part (c)

In this part, candidates were tested on their knowledge of condensation polymerisation. The structure of a polyamide, **B**, formed from the condensation polymerisation of amino acid molecules was shown, and candidates were asked to (i) identify the type of polymerisation involved, (ii) draw the monomer formed when the polyamide B undergoes acid hydrolysis and give one difference in the reaction conditions required for acid hydrolysis when compared to enzyme hydrolysis.

Candidates' Performance

The majority of candidates responded correctly to Part (i). In Part (ii), a small percentage of candidates correctly drew the structure of the amino acid. Most candidates indicated that acid hydrolysis required a higher temperature than enzyme hydrolysis.

Common Incorrect Responses

Part (c) (ii) (a)

- Structure of a di-acid was given.
- Structure of a diamine was given.
- Structures with incomplete carboxylic acid or amino acid end groups were given.

Part (ii) (b)

- "One requires a higher temperature" and not stating which one does.

Expected Responses

- The monomer has one amino ($-NH_2$) and one carboxylic (-COOH) end group at either end of the molecule.
- Acid hydrolysis requires a lower pH (or higher acid concentration). Enzyme hydrolysis requires a lower temperature (body temperature).

Question 4

Syllabus References: A2.8, 4.1, 4.2; B2: 2.1, 4.1

This question tested knowledge of the basis for assigning elements to groups and periods, the reduction of metal oxides by electrolytic or chemical reduction, writing ionic equations for displacement reactions and covalent bonding. Most candidates scored seven (46.7 per cent) or more marks for this question.

Candidates' Performance

Part (a)

For the most part, candidates were able to explain the basis for using the electron configuration to assign elements to groups and periods. Some candidates chose to write unnecessary information on periodic trends and gained no marks for their efforts. In a few cases, candidates were able to give the correct electron configuration of an element but incorrectly identified its group or period.

Part (b)

Most candidates correctly identified aluminium as the element whose oxide could be reduced by chemical reduction. It was expected that candidates would deduce that there were strong bonds formed between aluminium and oxygen and that electrolytic reduction was used as chemical reduction and would not be powerful enough to extract the aluminium. Although many candidates knew the difference between chemical and electrolytic reduction, they were unable to offer suitable explanations for electrolytic reduction being used to extract aluminium from its oxide and so lost two of the three marks in this section. Many associated the extraction with the position of the element in the reactivity series saying that as aluminium was high in the series, it would be extracted by electrolysis. The comparison of the two processes was missing from many of the responses. Many candidates seemed not to know that coke was a reducing agent.

In identifying elements that could participate in a displacement reaction, many candidates chose elements that were not in the table given, although the question required that elements should be selected from the table. The concept of a displacement reaction was fairly well understood. However, candidates lost marks because they were unable to write a balanced ionic equation inclusive of state symbols. No marks were awarded for selecting zinc and copper in response to Part (b)(ii) as this example was actually given on the question paper and these elements were not included in the table given.

Part (c)

The majority of candidates correctly identified covalent bonding as that in the compound iodine monochloride. Covalent bonding was usually well explained. However, far too many candidates lost marks because they were unable to show the correct representation of the covalent bond formed between iodine and chloride.

Common Incorrect Responses

- Identifying sodium, magnesium and potassium as examples of elements that can be extracted from their oxides by electrolytic reduction.
- Failure to show all electrons in the outer shell of the elements participating in the covalent bond.
- Failure to balance both the charge and the elements for ionic equations.
- Attributing the placement of elements to group to the valency of the element.

Question 5

Syllabus References: B2: 3.1, 5.3, 7.1, 7.2 and A 3.4

Candidates were tested on their knowledge of the industrial preparation of ammonia, and the preparation and identification of ammonia in the laboratory. They were also required to write equations relating to the oxidation of nitrogen(II) oxide to nitrogen(IV) oxide and the conversion of nitrogen(IV) oxide to nitric acid.

Generally, the question was poorly done, with approximately 75 per cent of the candidates scoring between zero and five (33.3 per cent) out of the possible 15 marks, with another eight per cent not attempting the question.

Part (a)

Candidates were required to give **(i)** the name of the catalyst and the temperature used in the manufacture of ammonia **(ii)** ONE reason why the temperatures currently used in the manufacture of ammonia make the process cost effective and **(iii)** a reason for the step (labelled as D) used for the recycling of un-reacted starting material (nitrogen and hydrogen) on the flow diagram for the manufacture of ammonia.

Candidates' Performance

More than 50 per cent of the candidates scored at least one of the two marks for Section (i). Section (ii) seemed to be the most difficult for the candidates, even with those candidates who had good scores on the question. For Section (iii), most candidates were able to correctly identify the recycling step.

Common Incorrect Responses

Part (a) (i)

- Enzyme
- Iron oxide
- Al
- Fe^{3+}
- Pt

Some candidates guessed and provided responses such as:

- 300^{o} atmospheres
- -92 kJ mol^{-1}

Most candidates wrote at length about the cost of equipment, with responses such as:

Part (a) (ii)

- It is cost effective because they need to get equipment that can supply the temperature necessary for the reaction to occur.
- Because the temperature is so high, the cost of materials and equipment (needed to heat and compress) to give out the heat energy is high and costly.

Part (a) (iii)

Step D in Figure 4 was important as:

- A way of purifying the ammonia
- Gases were being recycled and condensed into a liquid
- A step used to prevent air pollution
- Liquid ammonia was being recycled

Expected Responses

The correct catalyst is finely divided iron (iron was accepted) and the temperature range is 300^{o} – 600 ^{o}C. Although the reaction is exothermic and lower temperatures would shift the equilibrium to the products (giving higher yields), lower temperatures would make the reaction rate too slow to be economical. Step D is used to recycle the unreacted starting materials (hydrogen and nitrogen), which make the process more economical.

Part (b)

Candidates were required to (i) write a balanced equation to show the laboratory production of ammonia and (ii) describe a suitable test for identifying ammonia.

Candidates' Performance

Many candidates seemed not to know the basic steps involved in the laboratory production of ammonia, even though this is a part of the qualitative analysis. Many of those who got the equation correct omitted a source of heat. In Part (ii), the majority of the candidates gave correct answers.

Common Incorrect Responses

Part (b) (i)

- Heating ammonium hydroxide.

Part (b) (ii)

Some candidates wasted time describing the production of ammonia. Some incorrect responses were:

- Glowing splint would be re-lit.
- Used a pungent smell to identify ammonia.
- Changed blue litmus paper to red.

Expected Responses

Heating of any ammonium salt with a base will produce ammonia gas. The correct ionic equation for Part (i) is,

$NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$

For Part (ii), the correct responses are:

- Damp red litmus paper changes to blue in presence of ammonia.
- Dense white fumes are produced with hydrogen chloride gas.

Part (c)

Candidates were required to (i) write balanced equations for the oxidation of nitrogen(ii) oxide to nitrogen (IV) oxide, and the oxidation of nitrogen(IV) oxide to nitric acid in the presence of water and (ii) give two uses of ammonia.

Candidates' Performance

Even though the names of the reactants and products were given in each case, many candidates had difficulty with oxidation numbers, writing the correct chemical formulae, and balancing the equations in Part (i). Most candidates were aware of the industrial and home uses of ammonia, and gave correct responses to Part (ii).

Expected Responses

In Part (i), the correct responses are:

- $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
- $4NO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq)$

Candidates should be made aware of the nomenclature with and without oxidation numbers, for example, nitrogen monoxide ≡ nitric oxide, nitrogen dioxide ≡ nitrogen(IV) oxide.

Uses of ammonia include the production of fertilizers, cleaners and urea, also testing for metal ions.

Question 6

Syllabus Reference: C6.2, 6.5, 6.8, 6.10

Approximately 10 per cent of the candidates chose this question. Those who did, showed some awareness of the chemistry of common materials found around the home.

Part (a)

Candidates were expected to state what is meant by

- plasticity – the ability to be moulded
- porosity – ability to give up water without cracking
- vitrification – the process to become glossy.

They were also required to suggest some of the benefits of the plasticity and porosity of clay.

Candidates' Performance

Part (a) was poorly done by many candidates. They confused the phrases "what is meant" with "suggest a reason".

Part (b)

Almost all of the candidates gave the component of cement as calcium carbonate, limestone, silica or klinker. They also gave correct ingredients of concrete. Section (ii) was most problematic for the majority of the candidates as they were unable to provide a suitable response for why the floor was dampened while hardening.

Part (c)

This part of the question differentiated the stronger from the weaker candidates as the weaker candidates did not know that the dampening of clay would have the opposite effect to the dampening of concrete.

Expected Responses

A suitable response for the plasticity of clay was that it allows pottery to have a variety of uses due to different shapes such as pots, jars. Porosity is important as it helps the clay object to keep its shape without cracking.

Concrete is normally dampened during hardening as:

- Water helps to form hydrates.
- These hydrates are silicates, thread-like crystals.
- The hydrates hold the components of the concrete.
- The concrete floor would crack if not dampened.

As water makes clay soft, dampening it during the drying process would retard its ability to dry and the object would lose its shape.

Question 7

Syllabus References: C 6.2, 6.5, 6.8, 6.10; B2: 7.1

The average mark was 9.4 out of 15 or 62 per cent of the score. Sixty-nine per cent of the candidates scored a mark of 8 (53 per cent) or more. The majority of the candidates displayed an awareness of the inter-relationship among Chemistry, Biology, Ecology and Agricultural Science. As a result of this reinforcement, the majority of the candidates scored high marks.

Parts (a) (i) and (ii)

Candidates were required to define ‘humus’ as it relates to soil, and state three reasons why humus is an important component of soil.

Candidates’ Performance

These parts were well done with candidates being able to correctly identify and define humus and humus content in soil as dead and decaying organic (plant and animal) matter. Popular responses were humus is the organic substances in the soil and it

- is necessary to retain moisture
- provides nutrients
- aerates the soil
- improves crumb structure
- provides a home for microorganisms.

Common Incorrect Responses

- Humus is the top layer of the soil.

Expected Responses

Definition: Humus is the organic matter of the soil.

Reasons for the importance of humus: more efficient use of nutrients due to water held in humus, aids in moisture retention, improves soil structure allowing diffusion of air, reduces the tendency for minerals to be flushed out to the lower levels of soil, increases soil fertility, creates an environment that supports living organisms necessary for the conversion of soil nutrients to plant food, holds the soil together and helps prevent soil erosion and allows “excess water” loss thus preventing water logging.

Part (b)

Candidates were required to correctly identify a test for the ammonium ion in a soil sample.

Candidates’ Performance

This part was problematic for the vast majority of the candidates. *It appears as if the candidates who gave correct responses were the ones who actually carried out the test as suggested on page 60 of the syllabus.* A number of candidates did not know the formula for the ammonium ion and some referred to it as the ‘ammonia ion’.

Common Incorrect Responses

- Fe^{2+}, Pb^{2+}, Na^{+} and other ions.

Expected Responses

NH_4^+ ion.

Part (c)

Candidates were required to give one advantage and one disadvantage each for biological and chemical control of pests.

Candidates’ Performance

Some candidates confused chemical control with the use of chemical fertilizers. Better responses for chemical control included: ‘it is fast acting and easy to use’ being an advantage, and ‘it is expensive and kills useful organisms’ as a disadvantage, and for biological control, an advantage is ‘it does not have to be reapplied’ and a disadvantage is ‘it affects the ecosystem and the biological control eventually becomes a pest’.

Expected Responses

Chemical control, advantages: easy to apply, works quickly, broad spectrum of activity, can be selective, more easily available.

Chemical control, disadvantages: may be costly in the long term, pests may build resistance, toxic upon ingestion/inhalation, undesirable environmental consequences, may kill useful insects.

Biological control, advantages: once successful, does not need to be reapplied, increases diversity of the ecosystem, poses no environmental threat.

Biological control, disadvantages: takes much longer than chemicals to see a response, may upset ecological balance, may themselves become pests, migration or death of control.

Part (d)

Candidates were required to (i) give the meaning of hydroponics and (ii) state two advantages and two limitations of setting up a hydroponic farm.

Candidates' Performance

Many responses to Part (i) were vague as they did not associate hydroponics with a soil-less culture or an inert medium. However in Part (ii), the advantages of hydroponic farming were well stated, for example, growing of out-of-season crops, maximising use of land space, requiring a smaller labour force, greater crop yields. Some candidates had problems in identifying the limitations, and in some cases candidates misinterpreted the phrase 'cost effective' to mean expensive. Some good responses to limitations include: it is expensive to set up, it is a mono-culture, restricted to one type of crop, high technical expertise required, requires constant monitoring of the hydroponics farm, cultural acceptance of crops grown using hydroponics.

Common Incorrect Responses

- Some stated, loosely, that hydroponics is the growing of plants in water.

Expected Responses

Hydroponics is the process of growing of plants in a soil-less culture. This may include the use of water only, or an inert medium such as sand or gravel.

Advantages: no weed problems, answer to reduced arable land space, requires a small labour force for maintenance, no nutrient-deficient crops, crops available out of season.

Limitations: range of crops successfully cultivated is limited, anchorage and support of roots must be catered for, needs great care and monitoring, employees need a high level of technical knowledge, expensive to set up, societal acceptance of crops may be limited.

Perhaps, by visiting a hydroponics farm, the reinforcement of the theory would be achieved.

Paper 03 – School-Based Assessment (SBA)

General Comments

This year, there has been improvement in the quality of the samples submitted for moderation. There was a noticeable increase in the number of centres where the standard of the practical exercises was at least satisfactory. Teachers must again be commended for making an effort to improve the standard of the SBA and for their efforts to ensure maximum coverage of the syllabus as well as undertaking at least the minimum number of activities.

The points highlighted here should serve to aid teachers in further improvement of the SBA as well as assist in making the moderation process more effective.

SBA Samples

In general, the samples were presented in good condition but some emphasis should be placed on the following:

- Some books lacked a table of contents, page numbers and dates.
- Those laboratory exercises utilized for assessment should be clearly marked and identified in the candidates' books and the corresponding dates should be in the mark schemes
- The CHEM-3 form which shows the breakdown of marks for the individual skills should be completed and submitted for moderation.

Equations

This year there was an increase in the number of centres which adequately utilized equations. However, several errors were also noted.

- In many cases, students wrote incorrect equations which were not corrected by the teachers.
- Students should be encouraged to include state symbols whenever they are writing equations.
- Some equations which were incorrectly balanced were given as accurate by the teachers.

Greater emphasis should be placed on writing the correct chemical symbols. The most common error is with the use of capital letters. For example, in many cases the symbol for sodium chloride is being written as *NaCL* or *NACl* rather than *NaCl* and calcium carbonate as $CaCo_3$ rather than $CaCO_3$, and these were not corrected in the candidates' books.

Graphs

More emphasis also needs to be placed on graph work. Approximately 25 per cent of the centres submitted samples with unsatisfactory emphasis on graph work. In assessing graphs, the plotting of graphs should be assessed under the ORR skills and not the A/I skills. However, interpolation of the graphs can be assessed under the A/I skills.

Mark Schemes

It should be noted that a small percentage of the centres moderated (6 per cent) did not submit mark schemes. Additionally approximately 50 per cent of those submitted were inappropriate for at least one of the skills moderated. Teachers are encouraged, once again, to work together when planning and devising practical activities as well as constructing mark schemes. In a few instances, it was evident that two or more teachers submitted one group of five samples and only one teacher sent a mark scheme. In such cases, it was not possible to use the mark scheme submitted to moderate all the samples. Teachers are encouraged to co-ordinate common activities and mark schemes since one sample is required from a centre.

With respect to mark schemes:

- They should be specific for different laboratory exercises. In many cases teachers submitted one mark scheme to cover all the AI skills. Where this may be possible for PD skills, activities used to assess AI skills are too varied. This leads to an extremely vague and in most cases unusable mark scheme.

- The mark scheme should correspond to the laboratory exercises shown in the books. A common system should be used to identify the exercises in the books submitted with the appropriate mark schemes.

- Marks should not be lumped together. Instead, each mark should be assigned to a specific content item; for example, when more than one mark is allotted for a calculation, a breakdown of how individual or partial marks are allocated should be included in the mark scheme. If more than one skill is assessed per activity then the marks allotted for each skill must be clearly demarcated.

- When students are expected to answer specific questions these questions, as well as their expected responses and the allocation of each mark, should be included in the mark scheme.
- For qualitative laboratory exercises, assessing ORR and AI skills, the unknown(s), tests carried out, the expected observation, as well as inferences, should be noted in the mark scheme.
- For PD skills, the mark scheme should include relevant details, for example, the problem statement given to students as well as possible solutions and variables.
- Ensure that an adequate number of marks are allocated for an exercise while noting that **CXC does not award half marks**. For example, do not allocate five marks for an exercise which has more than five tests. Scale down the total mark of the exercises if necessary.
- All marks should be converted to a mark out of 10.
- A maximum of two skills should be assessed per activity.

Planning and Design (PD) Skills

PD skills remain the most challenging of the skills to assess. In this regard, some extensive comments on PD activities are included which hopefully will assist in improving the assessment of this skill.

Some areas where improvement is necessary include:

- The problem statements
- Stating the hypothesis
- Recording of data to be collected
- Writing of the treatment of results
- Use of appropriate tense

Below are some very specific comments:

- Scenarios
  - Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise. These should also be included in the teacher’s mark scheme.
  - It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PDs) be found.
  - It is not recommended that students be left to generate the problems/scenarios on their own. However, in circumstances where this is done, these problems/scenarios should be vetted by the teacher to make sure that they are testable and chemistry-based.

- Hypothesis
  - The hypothesis should be testable. Consider the following scenario

    Scenario*: Four bottles which had lost their labels are now labelled A, B, C and D. It is suspected that they are a sulphate, chloride, carbonate and a hydroxide. Plan and design an experiment to determine the identity of these solutions*.

A non-testable hypothesis would be: *the identification of 4 solutions that have lost their labels.*

A testable hypothesis would be: The solutions are A- sulphate, B – carbonate, C – chloride and D – hydroxide.

- As much as possible, the manipulated variable should be included in the hypothesis.
- The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used in the experiment should be outlined in the hypothesis.

- Aim
  - The aim must relate to the hypothesis as well as the problem statement.
  - Students should be encouraged to specify the method or technique to be employed in the experiment. It should be the bridge between the method and the hypothesis.

- Procedure
  - Special attention must be placed on the tense used in the procedure. Students should write the procedure in the present or future tense. Any other tense is unacceptable.

- Expected Results / Data to be Collected
  - This particular area is not well understood and hence it is recommended that the term "data to be collected" be used rather than "expected results".
  - In this section the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis should be recorded.
  - The data to be collected may be presented in tabular form or as a description of specific data including units where appropriate.
  - Some examples:
    - When doing a titration the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to use it as data collected.
    - If chromatography is used, then the data collected should include the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin. R_f values should never be used as data to be collected since these are also calculated.

- Treatment / Interpretation of Results / Data
  - It is recommended that the term "results" be replaced by "data" in the heading in an attempt to make it clear that this section looks at how the data collected will be used at proving or disproving the hypothesis.
  - This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

- Some examples:
  - In a scenario where students are trying to find out which brand of vinegar is more concentrated the Interpretation of Data could be: *If Brand Y vinegar uses the least volume* **(Data to be collected)** *to neutralize x* cm^3 *of base then Brand Y is the most concentrated vinegar* **(stated in the aim)***, and therefore the hypothesis is supported.*
  - In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *if both brands of ink contain the same number of components with the same colour and are the same distance from the origin* **(data to be collected)***, then both brands of ink contain the same dye* **(stated in the aim)** *and therefore the hypothesis is supported.*

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

- Sources of error
  - This section should not be present in a PD lab since it refers to a lab that has been carried out.

In addition, the points listed below are worth repeating even though they have been stated in past reports.

Planning and Design (PD)

- All PD activities should be based on chemical concepts. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition, or any other non-chemistry discipline are not suitable. An example of an inappropriate example is: Plan and design an experiment to prove that *Women are smarter than men* or *Secondary school students are smarter than drop-outs.*
- It is recommended that activities that involve live specimens, for example, frogs or slugs should not be considered for Planning and Design.
- Students should undertake at least four PD activities over the two year period. When this is not done the students are at a disadvantage.
- Observations, calculations or diagrams should not be included in a mark scheme used to assess PD skills.
- Plan and design activities which have been carried out cannot be assessed for PD skills.
- Standard practical exercises which can be obtained from a chemistry text are inappropriate for PD activities. Some examples include:
  - *Plan and design an experiment to determine the effect of concentration on the rate of a reaction.*
  - *Plan and design an experiment to determine the products of electrolysis of* H_2SO_4 *using inert electrodes.*
  - *Plan and design an experiment to determine the conditions of rusting.*

Analysis and Interpretation (AI)

The Analysis and Interpretation (AI) skill continues to be one of the better-assessed skills. However, to ensure continued improvement the following points should be noted.

- Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should **not** be assessed under A/I.
- Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.

Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that the students understand what is required of them. In addition, calculations involving moles and volumes should be done from first principle using the unitary method. Again **CXC does not accept the use of the equation** $M_1V_1 = M_2V_2$**.**