# CARIBBEAN EXAMINATIONS COUNCIL

## REPORT ON CANDIDATES' WORK IN THE ADVANCED PROFICIENCY EXAMINATION

## MAY/JUNE 2011

## CHEMISTRY

## GENERAL COMMENTS

Chemistry is a two-unit subject with each unit consisting of three modules.

Both Units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 031 is the School-Based Assessment (SBA) and is examined internally by the teacher and moderated by CXC. Private candidates sit Paper 032 which is an alternative to the SBA.

Paper 01 consisted of 45 compulsory multiple-choice questions with 15 questions based on each module. Each module contributed 30 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 02 comprised six compulsory questions, two based on each module. Each question contributed 15 marks to the total 90 marks for the paper. This paper contributed 40 per cent to the unit.

Paper 031, the School-Based Assessment, comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 is an alternative to the SBA and comprises three compulsory questions focusing on candidate's laboratory experiences.

The number of candidates writing the Unit 1 examination decreased by approximately two per cent from 4,549 in 2010 to 4,421 in 2011. However, the number of candidates writing the Unit 2 examination increased by approximately 12 per cent, from 2,832 to 3,168 in 2011.

## DETAILED COMMENTS

### UNIT 1

### Paper 01 – Multiple Choice

Performance on this paper was good. Candidates were able to answer most of the questions correctly. The greatest challenge was with items testing Kinetics and Equilibria (Module 2).The mean score on the paper was 59.7 per cent and the standard deviation 16.0.

### Paper 02 – Structured/Essay Questions

**Module1: Fundamentals in Chemistry**

Question 1

Syllabus Objectives: 1.1, 4.1, 4.2, 4.3
Mean: 5.47; Standard Deviation: 3.50

This question sought to assess candidates' knowledge of

- Daltons's theory of the atom
- the relative reducing properties of zinc and copper and the experimental verification.

Candidate performance was modest. A significant number of candidates had difficulty describing the ideas contained in Dalton's atomic theory.

It was somewhat surprising that candidates experienced difficulty providing answers which would have indicated exposure to a classical experiment to establish the relative reducing abilities of the metals zinc and copper. Difficulty associated with the writing of redox equations was again clearly evident.

Teachers are reminded that the presentation of chemical concepts and theories must be placed in a historical context since science involves the progressive interpretation of empirical data.

**Module 2: Kinetics and Equlibria**

Question 2

Syllabus Objectives: 5.1, 5.2, 5.3, 5.4, 5.5
Mean: 4.30; Standard Deviation: 2.95

Candidates were required to demonstrate an understanding of

- solubility and solubility product
- common ion effect

They were also required to

- perform associated calculations
- describe the experimental determination of the solubility product of barium hydroxide, $Ba(OH)_2$.

This question was generally not very well answered. A large number of candidates thought that concentration was a factor that influenced solubility, while the crucial notion that the common ion effect involved sparingly soluble salts was not widely appreciated.
The balancing of the equation in Part (c) (i) and the writing of the solubility product expression in Part (c) (ii) were found to be problematic.

The description of an experimental procedure in determining the solubility product for Part (d) was very poorly answered.
The teaching of the concepts above need to be more thorough and students need to be afforded the relevant experimental experience as reinforcement.

**Module 3: Chemistry of the Elements**

Question 3

Syllabus Objectives 2.1, 2.3, 2.4, 2.5
Mean: 4.26; Standard Deviation: 2.67

The question required candidates to demonstrate knowledge of the chemistry of the Group II elements and an experimental approach to the comparison of the solubilities of their respective sulphates(VI).

Candidates experienced great difficulty in responding correctly to this question. They were generally able to supply the equation for the formation of the $M^{2+}$ ion, Part (a), and appropriate uses of calcium carbonate, Part (e).

Candidates found it difficult to express coherently the differences in the reactivity of the elements presented. They were able to note the reduction of the value of the second ionization energy as the Group was descended but were unsure of how to apply this information in answering the question.

The inability of candidates to comment correctly on the solubility of the radium sulphate (VI) and to write the equation for the decomposition of its nitrate (V) was surprising. Again, the seeming lack of practical exposure to course materials was seen in the poor responses to Part (d).

**Section B**

**Module 1: Fundamentals in Chemistry**

Question 4

Syllabus Objectives: 5.1, 5.3, 6.8, 6.9
Mean: 5.93; Standard Deviation: 2.95

This question required candidates to

- demonstrate knowledge of the kinetic theory as it applies to an ideal gas
- use the ideal gas equation to perform calculations
- provide a definition of Hess's Law
- construct a Born-Haber cycle as illustrating Hess's Law.

Candidates' performance on this question was generally modest. They were able to earn marks from answers to Parts (a), (b) and (c) (i). They encountered difficulty in correctly constructing the Born-Haber cycle for magnesium oxide.

Attention needs to be given to the energy changes involved, especially the bond dissociation energy of gases.

**Module 2: Kinetics and Equlibria**

Question 5

Syllabus Objectives: 2.1, 2.3, 2.5, 2.6, 2.2, 2.7
Mean: 4.10; Standard Deviation: 3.17

This question was based on aspects of equilibrium and candidates were required to show their understanding of

- dynamic equilibrium and its characteristics
- equilibrium constant, $K_c$, its applications and associated calculations

This question was poorly answered. Candidates were able generally to gain marks from Parts (a) and (c) (ii). Candidates found it challenging to define the equilibrium constant, $K_c$, often describing it as the ratio of the concentration of products to reactants as well as neglecting to comment on the significance of its magnitude.

Part (c) (i) provided the greatest challenge. This involved a calculation of the equilibrium concentrations of species involved in the decomposition of dinitrogen tetroxide, $N_2O_4$. The major challenges encountered were in deducing the number of moles of the gases at equilibrium and that *the small value of $K_c$ allowed the approximation shown below.*

| | $N_2O_4(g)$ $\rightleftharpoons$ | $2NO_2(g)$ |
|---|---|---|
| initial | 0.800 | 0 |
| change | $-x$ | $+2x$ |
| equil. | $0.800 - x$ | $2x$ |

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}, \quad \text{therefore} \quad \frac{(2x)^2}{(0.8\text{-}x)} = 4.66 \times 10^{-3}.$$

Since $K_c$ is much less than 1; $x$ is negligible, therefore $0.8 - x = 0.8$.

It was evident from the responses that greater care needs to be taken in the teaching of this topic and that future candidates need much more practice in performing such calculations.

**Module 3: Chemistry of the Elements**

Question 6

Syllabus Objectives: 3.1, 3.2, 3.3
Mean: 5.40; Standard Deviation: 2.56

This question tested candidates knowledge of the chemistry of the Group (IV) elements.
Candidates generally found this question to be challenging. They found Parts (a) and (e) to be easy and the majority gained full marks; however, thereafter the gaining of additional marks was rather difficult.

Candidates provided confusing and sometimes conflicting explanations for explaining the trends asked for in Part (b). The hydrolysis of silicon(IV) chloride by its exposure to the atmosphere was not very well understood – some candidates suggested that the reaction involved oxidation while others opted for displacement.

Candidates also failed to connect volatility with intermolecular forces, while many of them referred to the white fumes as hydrochloric acid.

## Paper 032−Alternative to School−Based Assessment

Candidate performance remained fairly stable. The maximum marks available was 48. The mean score was 22.07 (46.07 per cent) and the standard deviation was 11.22.

Question 1

The question tested candidate's ability to execute the process skills associated with the successful completion of an exercise in qualitative volumetric analysis and correctly calculate the solubility product $K_{sp}$ of $Ca(OH)_2$ .

Candidate performance on the actual titration was satisfactory; however, some difficulty was experienced in the required calculations.

Question 2

This question utilized the data analysis format. Candidates were asked to

- tabulate data of temperature and time provided
- calculate the enthalpy change of neutralization.

Most of the marks obtained by candidates were for the tabulation and plotting of the resulting graph. Some candidates found it challenging to explain the shape of the graph and calculate the required enthalpy change of neutralization.

Question 3

This question focused on planning and designing an experiment to investigate the variation in the reactivity of the Group VII elements.

The main areas of concern were

- the identification of various variables
- the writing of the appropriate hypotheses.

## UNIT 2

### Paper 01−Multiple Choice

Performance on this paper was good. Candidates answered most questions correctly.
Of the three Modules, the greatest challenge for candidates was with items testing Industry and the Environment (Module 3). The mean score was 65.5 per cent and the standard deviation 16.2.

### Paper 02−Structured/Essay

**Module 1: The Chemistry of Carbon Compounds**

Question 1

Syllabus Objectives: 2.4, 2.6, 2.9
Mean: 6.12; Standard Deviation: 4.16

Candidate performance was moderate. This question required candidates to demonstrate their competence in the area of group analysis and the mechanisms associated with nucleophilic substitution.

Responses to Parts (a), (b) (i) and (c) (ii) were generally satisfactory. The main challenge was in explaining the mechanism of the reaction in Part (b) (i) using curved arrows. Candidates are still not clear about the direction of electron movement as indicated by the arrows. They also need to be more careful in describing the conditions under which organic reactions occur.

**Module 2: Analytical Methods and Separation Techniques**

Question 2

Syllabus Objectives: 1.1, 1.2, 1.3
Mean: 5.78; Standard Deviation: 2.45

Candidates were required to supply responses in the areas involving

- knowledge of concepts of precision and accuracy
- the calculation of standard deviation and its implications
- an experimental knowledge of the calibration of a pipette.

Candidates showed a satisfactory understanding of the concepts above, in Parts (a) and (b), as well as in the calculation of standard deviation in Part (c) (i). Again, weakness was evident in the inability to outline experimental procedures that were required in Part (d).

**Module 3: Industry and the Environment**

Question 3

Syllabus Objectives: 3.1, 3.2, 5.1
Mean:8.38; Standard Deviation: 3.14

This question focused on the distillation of crude oil and the process of fermentation.

Candidate performance was generally good except for some difficulty with the concept of reforming in Part (b) and some aspects of fermentation in Part (e).

**Module 1: The Chemistry of Carbon Compounds**

Question 4

Syllabus Objectives: 3.1, 1.4, 1.7
Mean: 5.00; Standard Deviation: 3.00

The topics tested in this question were

- structural isomerism
- combustion analysis
- acidity of organic compounds.

Overall, candidate performance was rather weak. Candidates were able to submit correct answers to questions relating to structural isomerism, Part (a), but performed poorly in their attempts at answering Parts (b) and (c) which related to the other two topics. Candidates seemed to be surprised by the question on combustion analysis while the explanation concerning the acidity of the given organic compounds demonstrated inadequate understanding of the principles involved.

**Module 2: Analytical Methods and Separation Techniques**

Question 5

Syllabus Objectives: 5.1, 5.2, 5.4, 5.5
Mean: 4.67; Standard Deviation: 3.83

This question tested the theory and simple applications of UV/VIS spectroscopy.
Responses from candidates indicated a weak understanding of this analytical technique.
This weakness was evident in the majority of the sections of the question. These included the

- concept of chromophore
- use of the Beer Lambert equation
- significance of calibration curves and standard solutions as they apply to UV/VIS spectroscopy.

It is evident that more attention needs to be given to these areas in the completion of the syllabus.

**Module 3: Industry and the Environment**

Question 6

Syllabus Objectives: 9.7, 9.1
Mean: 6.71; Standard Deviation3.64

Candidates were tested concerning their knowledge of the nitrogen and carbon cycles and the preservation of the levels of stratospheric ozone.

Candidate performance was satisfactory. Candidates were able to gain at least two marks in identifying the components of the nitrogen cycle as well as supplying acceptable answers to the disturbing of the balance of the two cycles by human activity.

The responses regarding the preservation of ozone levels proved to be a challenge for the majority of candidates especially in writing appropriate equations.

## Paper 032 – Alternative to School−Based Assessment (SBA)

Candidate performance on Paper 032 showed modest improvement.

The maximum marks available was 48. The mean score was 19.25 (40.1 per cent) and the standard deviation was 6.94.

Question 1

This question involved the testing of organic compounds to determine their relevant functional groups. Candidates generally manifested good manipulative skills and were also able to correctly identify the relevant functional groups.

Question 2

The application of the concepts *equivalence point* and *strength of acid* were challenging areas for the majority of candidates.

Question 3

The questions on planning and designing were inconsistently answered. The main area of concern for candidates were

- the identification of the various variables
- the writing of appropriate hypotheses.

## Paper 03/1 – School−Based Assessment (SBA)

Submissions

Most centres submitted the requested five samples, however there were a few whose samples did not correspond with the computer−generated sample printout as issued by the Council. It is to be noted that this is a requirement stipulated by the Council and as such teachers and students are expected to comply with this instruction.

In the case of the laboratory books, they are required to contain

- a table of contents indicating the skills assessed, page number and date of the practical exercise
- the practical exercises for which assessment was done (these must be clearly marked
- the names of the practical exercises at the beginning of the respective reports.

Mark Schemes

Generally, the mark schemes submitted were appropriate for most skills. In a few instances, the mark schemes were not detailed enough and this made moderation challenging.

Mark schemes are required to provide the following:

- A clear indication for the awarding of *each* mark−this is especially important where multiple marks are awarded for a particular question or part thereof
- Names of unknown compounds and ions used in qualitative and quantitative analysis assignments
- Expected observations and inferences in qualitative analysis assignments
- Marks awarded for calculations and equations
- Criteria for Manipulations and Measurement (MN) assignments
- Problem statements for Planning and Designing (PD) activities

Syllabus Coverage

This aspect was well done and teachers are to be commended for seeking to include activities from most areas of the syllabus.

Assessment of Skills

While it is heartening to note that some skills were assessed more than twice, it must be borne in mind that only *two* assessments for each skill should be selected and submitted for moderation. These should be clearly indicated in the table of contents at the front of the laboratory book.

*Observation/Recording/Reporting (O/R/R)*

There has been some improvement in the assessment of this particular skill, however, the following should be noted:

In reporting in the area of qualitative analysis, 'no reaction', 'insoluble', 'soluble', 'acidic' and *'basic'* are not regarded as observations but inferences. Instead the following should be used: *'no observable change/no visible change/no apparent reaction', 'solid/precipitate dissolves'.*

*Analysis and Interpretation (AI)*

The assignments used to test this skill need to be more challenging, for example, calculations based on volumetric analysis should come primarily from areas of the syllabus which do not overlap with the CSEC syllabus, that is, these should be at the advanced proficiency level. The award of marks for analysis of graphs and discussions based on observations or results of practical activity is encouraged. However, the use of questions based solely on theory is unacceptable for assessing this skill as it provides no measure of analysis or interpretation.

*Planning and Designing (PD)*

Although there has been some improvement in the assessing of this skill, teachers still exhibit great difficulty in formulating problem statements capable of generating hypotheses with appropriate variables. In many instances, problem statements were unacceptable either because no viable

hypothesis was possible or all that was required of the student was the 'lifting' of the material directly from a text book. A popular unacceptable assignment involved the experiment to determine the order of the iodine/propanone reaction.

Teachers are reminded that acceptable PD assignments should *pose a problem for candidates to solve using concepts contained in the syllabus. These problems should encourage hypothesis making, be conceptualized in 'novel' situations and should not be activities previously done or readily available in textbooks.*

Summary

- Teachers are reminded that credit is to be given for the individual work of students, especially for discussions, calculations and PD activities.
- There was evidence of increasing collaboration between teacher/student and student/student in a number of centres in the presentation of student responses.

- Care must be taken to ensure the accuracy of content communicated. Instances were found where inaccurate information formed the basis for the awarding of marks thereby placing students at a disadvantage.
- The integrity of some of the SBA samples submitted continue to be of grave concern.

There is evidence to indicate that teachers are using practices that undermine the pedagogical philosophy of the SBA component of the syllabus. The SBA component has been designed to form part of the continuous assessment of students in the area of the development of their practical and problem-solving skills.

The following quotation from the CAPE Chemistry Syllabus, May/June 2007/2008 is of particular relevance.

> *Internal Assessment is an integral part of student assessment in the course covered by this syllabus. It is intended to assist students in acquiring certain knowledge, skills, and attitudes that are associated with the subject. The activities for the Internal Assessment are linked to the syllabus and should form part of the learning activities to enable the student to achieve the objectives of the syllabus.*