CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2013

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, the School-Based Assessment (SBA), is examined internally by teachers and moderated by CXC. Private candidates write 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, comprised laboratory exercises and contributed 20 per cent to the unit. Paper 032 comprised three compulsory questions focusing on candidates' laboratory experiences.

Overall, performance in 2013 declined when compared with 2012.

Performance across the two papers in both units showed a vast disparity, with candidates doing very well on Paper 01 while performing poorly on Paper 02.

Some of the underlying causes for the poor performance on Paper 02 included

- the inability of candidates to operate above the basic level of comprehension
- challenges with questions involving the use of application, analysis and synthesis
- severe limitation of the use of technical language to explain chemical concepts
- inadequate exposure to practical activities.

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 continues to be with items testing Kinetics and Equilibria as well as qualitative and quantitative treatment of first-order equations (Module 2).

Paper 02 – Structured/Essay Questions

Module1: Fundamentals in Chemistry

Section A

Question 1

Syllabus Objectives: 4.1, 4.2, 4.3
Mean: 4.52; Standard Deviation: 2.43

This question tested candidates' understanding of the concepts of oxidation/reduction, the use of equations in representing such reactions and the application with respect to the halogens.

Candidate performance was very weak. Most candidates were able to define these concepts in terms of electron transfer and/or oxidation numbers, however, a minority opted to use oxygen as the basis for their definition. It should be noted that the last approach represents a very narrow perspective and explanations involving the two former notions should be adopted. There was some compensation as candidates gained additional marks from Parts (b) (i) and (iii).

Candidates had great difficulty writing the relevant half equations and demonstrated a lack of awareness of the experimental application of these concepts in the understanding of the chemistry of the halogens.

Module 2: Kinetics and Equilibria

Question 2

Syllabus Objectives: 4.1, 4.2, 4.3, 4.4
Mean: 3.42; Standard Deviation: 2.58

This question focused on buffer solutions (their operation and the associated experimental and mathematical applications) and was very poorly answered. The area of definition was the only component of the question with which candidates showed any measure of competence.

The answers involving the operation of buffers showed either an incomplete or a confusing comprehension of the concepts involved. Candidates also found it challenging to manipulate the information provided to make the calculations requested, while familiarity with the practical details of the determination of the pH of such solutions was glaringly absent.

It would appear from responses submitted by candidates that they were inadequately prepared for this topic. Teachers should therefore seek to address these deficiencies by providing appropriate learning activities in the areas of chemical equilibrium, acidity, and associated concepts, both experimental and theoretical.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 5.8, 6.1, 6.2, 6.5, 6.6
Mean: 3.95; Standard Deviation: 2.66

This question assessed candidates' competence in the area relating to the identification of both anions and cations.

Candidate performance was poor considering the significant overlap in this area with the CSEC syllabus.

The unsatisfactory level of responses in the completion of the laboratory report in Part (b) pointed to gaps in this area of knowledge. The majority of candidates found great difficulty in deducing the presence of the sulfate (IV) ion, SO_3^{2-}, which lead to the loss of marks in the writing of the subsequent equations.

The majority of candidates was awarded marks for answers to Part (a) which was handled satisfactorily.

Performance on this question continues to confirm the observation that the level of exposure to activities of an experimental nature is undesirably low.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 6.1, 6.2, 6.3, 6.9
Mean: 5.76; Standard Deviation: 3.87

This question tested candidates' comprehension of a number of concepts under the topic Energetics. These included:

- Standard enthalpy of formation
- Exothermic and endothermic changes in enthalpy
- Construction of Born–Haber cycle

Candidate responses were inconsistent, resulting in an overall weak performance. Marks were obtained across the various sections of the questions; however, these were not sufficient to produce an acceptable level of performance.

The following presented candidates with significant challenges:

- The relationship between the electron affinity of the oxygen atom in the production of the oxide ion, O^{2-}
- The lattice energy and the enthalpy change of formation of CaO(s) in the construction of the Born–Haber cycle

- The distinction between *exothermic enthalpy change* and *endothermic enthalpy change* (Attempts generally resulted in confusing presentations.)
- Calculations using information provided by the Born–Haber cycle

Candidates need to engage in more activities surrounding the construction of a number of Born–Haber cycles for different compounds along with the relevant calculations. This would assist in improving performance in this area.

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 1.3, 1.4, 1.6, 1.8
Mean: 5.21; Standard Deviation: 4.05

Candidates were tested in this question on their

- understanding of the effects of temperature and catalysts on reaction rates
- ability to perform calculations using information about initial rates.

While the general level of performance was weak, some candidates demonstrated a satisfactory level of competence in these areas.

Candidates showed a general acquaintance with the subject matter in the first area of testing. However, the absence of an accurate and complete understanding was noted in the frequent interchange of distribution curves with respect to the relevant temperatures (T_1, T_2) and the failure to clearly explain the relevant effects.

In the second area of testing, there was confusion evident in the choice of information made to deduce the rate equation and the overall order of the reaction.
The importance of units in the various calculations should be emphasized.

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 5.2, 5.3, 5.4, 5.7
Mean: 4.69; Standard Deviation: 3.80

This question focused on the chemistry of the first row of transition elements. The majority of candidates obtained marks in Part (c) for identifying the shapes of the complex ions.

Candidates had difficulty answering questions which required explanations and/or applications of chemical principles. This was exemplified by the

- inadequate explanation of d-orbital splitting as well as the relationship between absorption and emission of light in the formation of coloured ions in transition elements

- unsatisfactory application of electronic configuration in accounting for the stability of iron(III) with respect to iron(II).

Candidates were challenged in accounting for the gradual decrease in atomic radius across the first row of transition elements.

It would appear that this section of the syllabus would benefit from more careful attention by teachers in planning their overall teaching strategy.

Paper 032 – Alternative to School-Based Assessment

Syllabus Objectives: Module 3: 6.5.
Mean: 19:71: Standard Deviation: 7.44

Question 1

In this question, candidates were required to perform a practical exercise to test their competence in the identification of anions using the method of simple qualitative analysis.

An inadequate knowledge of the concepts underlying the tests required resulted in weak candidate performance. The lack of adequate practical activities was evident in the recurring unsatisfactory level of reporting/recording of observations.

Some of the inadequate/inaccurate reporting included expressions such as

- '*insoluble* precipitate formed'
- 'a *clear* solution was seen'/precipitate dissolves to form a *clear* solution'
- 'a *cloudy* solution formed'
- '*bubbles/fizzing* seen'
- '*white* solution formed'.

Teachers should seek to redress this deficiency in the preparation of students by affording students various opportunities to conduct practical assignments and practise the use of the appropriate language for chemical reporting.

Question 2

This question assessed candidates' ability to

- manipulate data pertaining to reaction rates
- interpret information presented in a graphical format
- display the skills associated with data collection and reporting.

Most candidates were able to correctly read the gas syringe, record the resultant data in the appropriate manner and draw the resultant graph. Candidates who correctly deduced the rates of reaction at the relevant times from the graph performed well. Generally, candidates faltered in their responses to Parts (d) ─ (g). The level of performance was inconsistent.

Question 3

This question tested candidates' level of competence in the various skills associated with the planning and designing (PD) of practical investigations.

Candidate performance was weakest on this question. In addition to the general inadequacies associated with this area, the lack of knowledge of the content relating to the question resulted in a low level of performance.

UNIT 2

Paper 01 − Multiple Choice

Performance on this paper was very good. Candidates answered the majority of questions correctly. The greatest challenge continues to be with questions testing Industry and the Environment, for example, free radical reactions in the upper atmosphere (Module 3).

Paper 02 − Structured/Essay Questions

Section A

Module 1: The Chemistry of Carbon Compounds

Question 1

Syllabus Objectives: 2.9, 2.10, 2.12.
Mean: 3.47; Standard Deviation: 2.67

This question tested candidates' knowledge of the chemistry of the functional groups of esters and carbonyl compounds. It was poorly done.

The question highlighted the dependence on rote learning by candidates and the consequent inability to respond to instances where application of knowledge is required. It is critical that teachers re-examine present teaching methodology to include opportunities to develop the critical thinking skills of prospective candidates.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 6.1, 6.2, 6.4, 6.5
Mean: 6.48; Standard Deviation: 3.70

This question focused on infrared spectroscopy and its use as an analytical method. Candidate performance was modest.

Generally, candidates were able to

- cite examples of the use of this method
- interpret the information provided by spectrographs. (Parts (a) ─ (c))

Candidates, however, found challenging the

- description of the practical preparation for sample analysis
- identification of the characteristic properties of molecules that are IR responsive.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 8.2 – 8.5
Mean: 7.33; Standard Deviation: 3.11

This question tested candidates' knowledge on aspects of the environment. These included

- processes which result in pollutants and oxygen entering waterways
- tests for the identification of such pollutants
- relation of eutrophication and water quality
- processes used for the treatment of water.

While some inconsistency in correct responses was observed, there was an overall satisfactory level of performance.

Candidates were able to obtain marks across the various components of the question.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 2.15, 2.16, 2.17
Mean: 4.68; Standard Deviation: 3.29

Candidates were required to respond to questions relating to the

- chemistry of phenols
- introduction of various species into the benzene molecule
- effect of such species on the reactivity of subsequent substituted molecules.

Candidate response to this question was weak.

The concepts surrounding substitution in the benzene molecule and the resulting explanation of the effect of such substituents on the electron availability within the benzene molecule presented a major challenge for candidates.

A significant number of candidates were unsure about the experimental conditions associated with many of the reactions as indicated.

Module 2: Analytical Methods and Separation Techniques

Question 5

Syllabus Objectives: 9.1, 9.4, 9.5
Mean: 3.40; Standard Deviation: 3.08

This question tested candidates' knowledge on a number of separation techniques and in particular the

- principle and application of partition coefficient in solvent extraction
- explanation of boiling point/composition curves related to the process of distillation of ideal liquid mixtures.

Candidates were generally able to define *partition coefficient* and earned marks in the identification of appropriate methods of separation in specific cases. However, severe deficiencies were exposed when attempts were made to perform the required calculation and interpret the boiling point/composition curve as presented.

Once again, candidates showed their incomplete apprehension of relevant concepts and limited mathematical skills, which at this level can be described as simple operations.

Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 2.1, 2.3
Mean: 5.93; Standard Deviation: 3.39

This question centred around the extraction and purification of aluminum oxide from its bauxite ore and its subsequent electrolysis leading to the production of the metal.

Given the prior introduction to this topic at the CSEC level, it was surprising that the level of performance was so weak.

Most candidates were able to identify the polluting by-product of the extraction of the oxide as well as the resulting environmental consequence. However, the writing of the relevant equations involved in the processes, both chemical and electrolytic, presented a challenge. Candidates demonstrated limited awareness of the benefits of the recycling of the metal.

Paper 032 – Alternative to School-Based Assessment (SBA)

Mean: 22.32
Standard Deviation: 9.41

Question 1

This question required candidates to perform a volumetric analysis involving a redox reaction. Candidates were required to standardize a solution of oxalate ions using a standard potassium manganate(VII) solution.

Candidates' performance was inconsistent. Many candidates were able to calculate the number of moles of manganite (VII) ions used in the titration. However, the subsequent calculations presented serious challenges.

Some observations that should be noted by teachers and candidates are:

- Titres should be recorded to two decimal places.
- Consistent results are achieved when two titres agree to within 0.10 cm^3.
- Volume to be used in calculations is the mean value of the consistent results.

Question 2

This question assessed candidates'

- knowledge of the principles of gravimetric analysis
- ability to perform calculations to determine the number of molecules of water of crystallization
- exposure to skills associated with data collection and reporting.

Candidates were able to tabulate the data provided. Parts (b)–(e) were answered with varying levels of success. However, the lack of competence in performing the necessary calculations continues to be a problem for candidates. A concerted effort needs to be made to address this deficiency.

Question 3

This question focused on candidates' level of competence in the various skills associated with the planning and design (PD) of practical investigations.

Candidates obtained marks for suggesting an appropriate hypothesis, however, some found it difficult to produce a corresponding aim of the experiment. Generally, the lists of reagents and equipment were satisfactorily presented. However, the description of a concise procedure (indicating the need for control of variables) was inadequate. Overall, candidates showed limited familiarity with experimental reporting and performance.

Paper 031 – School-Based Assessment (SBA)

Most centres complied with the guidelines for the submission of samples for moderation: however, teachers are reminded of the following:

- Samples submitted should correspond to those on the list that was computer generated by the Council.
- Laboratory books must contain a table of contents with the date of the practical, the page number and the skills assessed. Where more than two practicals are assessed for the same skills, the two to be moderated must be clearly identified.
- Mark schemes should be detailed so as to facilitate the smooth and accurate process of moderation. This should include the names of unknown compounds and ions, observations and corresponding inferences used in qualitative and/or quantitative analyses.
- Marks awarded for calculations, writing of equations and discussions should be clearly indicated.
- Problem statements for planning and design (P/D) activities must be included as part of the mark scheme.
- Criteria for manipulation and measurement must also be submitted.

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

There has been improvement in the assessment of this particular skill and teachers are to be commended. The following points, however, need attention:

- In the reporting of qualitative analysis, 'no reaction', 'insoluble', 'soluble', 'acidic' and 'basic' are not regarded as observations but inferences.
  The following should be used instead: *no observable change, no visible change, no apparent reaction, solid/precipitate dissolves.*
- Discussions and conclusions, calculations and information obtained from graphs are all to be assessed as analysis and interpretation (A/I).

Analysis and Interpretation (A/I)

The criteria testing this skill need to be more challenging. Calculations based on volumetric analysis should go beyond acid/base and include redox and back titrations. 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 Design (P/D)

Although there has been some improvement in the assessment of this skill, teachers still have great difficulty formulating problem statements capable of generating hypotheses and variables.

Care must be taken to ensure that problem statements do not lead to students reproducing material directly from textbooks, for example, requiring students to plan and design an experiment to determine the order of reaction between iodine and propanone. This type of assignment will be deemed unacceptable.

Problem statements should allow for multiple hypotheses and methods. Many mark schemes tend to be extremely rigid and students are expected to use only one particular method — this tends to limit creativity.

Assumptions, limitations and sources of error should not be assessed as one criterion. Students should be taught to appreciate the differences and be assessed appropriately.

Care must also be taken to ensure that the various activities relate to relevant areas of the CAPE syllabus. Activities involving objectives presented in Unit 1 should not be used as a Unit 2 assignment.

Integrity of Samples

There was an increase in the number of centres where teacher/student collaboration was evident.
Teachers are reminded that

- students are to engage in individual work, especially for discussion, calculation and planning and design (P/D) activities
- the SBA component of the CAPE course is intended to be developmental, involving continuous assessment of student skills and attitudes concerning a vital aspect of a chemist's work — experimentation. Teachers should therefore refrain from using the SBA as a form of summative assessment.