CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE
CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2009

CHEMISTRY

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GENERAL COMMENTS

Chemistry is a two-unit subject with each Unit consisting of three Modules. This is the second year of examination of both Units based on the revised syllabus and the new examination format. The Modules in the current syllabus are:

Unit 1

- Module 1 - Fundamentals in Chemistry
- Module 2 - Kinetics and Equilibria
- Module 3 - Chemistry of the Elements

Unit 2

- Module 1 - The Chemistry of Carbon Compounds
- Module 2 - Analytical Methods and Separation Techniques
- Module 3 - Industry and the Environment

Both Units are examined by three papers. Papers 01 and 02 are external examinations, while Paper 03 is the Internal Assessment and is examined internally by the teacher and moderated by CXC.

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 consisted of 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 03, the Internal Assessment, comprised laboratory exercises and contributed 20 per cent to the Unit.

This year a total of 4039 candidates registered for the Unit 1 examinations compared with 3484 in 2008, an increase of approximately 14 per cent; 2708 registered for Unit 2 compared with 2385 in 2008, an increase of approximately 13 per cent.

DETAILED COMMENTS

Paper 01

The performance on each of these papers was good. In each Unit, candidates were able to answer most of the questions correctly.

The mean score in Unit 1 was 56.9 per cent and standard deviation 8.10.

The mean score in Unit 2 was 61 per cent and standard deviation 7.12.

UNIT 1

Paper 02

Question 1

Specific Objectives: 1.7, 6.6
Mean: 4.06; S.D.: 2.57

This question sought to test candidates' knowledge on the line emission spectrum of hydrogen. Based on the responses of the candidates, this seems to be a neglected area of the syllabus. Many candidates could not give a simple sketch of the converging lines associated with the emission spectrum of hydrogen. In explaining the origin of the lines in the Balmer series, the majority of candidates demonstrated knowledge of electrons becoming excited and moving from lower to higher energy levels but could not give an account of what happens thereafter. Most candidates were aware that the Balmer series is associated with the visible region of the electromagnetic spectrum.

The weaknesses associated with this question were:

(i) Candidates continue to confuse atoms, elements and molecules – using these terms interchangeably.

(ii) In explaining the origin of the Balmer series, candidates had difficulties recognizing that the lines are the result of electrons falling from higher energy levels to the $n = 2$ energy level, giving rise to specific quanta of energy corresponding to the colours observed.

Most candidates were able to identify at least two errors in the apparatus set up to determine the combustion of ethanol.

It is recommended that candidates be prepared for all areas of the syllabus and not concentrate only on those areas from where they believe questions are most likely to come.

Question 2

Specific Objectives: 1.2, 1.3, 1.4
Mean: 9.37; S.D.: 1.76

Candidates were required to demonstrate their understanding of the factors which influence rates of reaction; to express rate data in graphical form, and to deduce order of reaction from the appropriate data.

Overall, candidates' performance was rather good. Part (d) presented the greatest challenge to candidates. Many candidates did not know the steps involved in the experiment to determine the rate of the esterification reaction. Despite the popularity of an esterification reaction as an example illustrating the rates of reaction, it was assumed that because the reagents were organic in nature, this experiment belonged in Unit 2 and cannot be used to highlight aspects of Unit 1.

It is recommended that the different aspects of chemistry be taught in an integrated manner so that candidates will be better able to apply chemical principles to a variety of situations.

Question 3

Specific Objectives: 5.2, 5.4, 5.10
Mean: 5.80; S.D.: 3.58

The objective of this question was to assess candidates' knowledge on the transition elements. Many candidates were inadequately prepared for the objectives tested by this question.

Weaknesses associated with this question are outlined as follows:

(i) Many candidates seemed unfamiliar with orbital diagrams. This was illustrated by the writing of numbers in the boxes provided, rather than drawing arrows.

(ii) Too many candidates were unfamiliar with the anomalies associated with the electronic configurations of chromium and copper.

(iii) The origin of colour in transition metal compounds seemed not to be clear in the minds of some candidates. Common errors included a failure to mention that the electronic transition was a d-d transition; colour was being produced as a consequence of the emission of light when electrons return from high energy to low energy d-orbitals.

Question 4

Specific Objectives: 2.7, 2.8
Mean: 4.03; S.D.: 2.90

This question tested candidates on their knowledge of intermolecular forces, and the origin and prediction of shapes of simple molecules and ions based on Valence Shell Electron Pair Repulsion (VSEPR) theory.

Although many candidates were able to state the basic principle behind VSEPR theory, several described its effect instead. Again, it seems that candidates were unclear about the definition of the terms, valence electrons, ions, atoms and molecules.

It was apparent from the responses to Part (c) (i) that some candidates were not taught dimerization as an example of the effect of hydrogen bonding in molecules.

Some candidates did not see the link between physical properties, such as boiling, and intermolecular forces of attraction between molecules.

Question 5

Specific Objectives: 2.5, 2.6, 2.7, 3.1, 3.3
Mean: 7.55; S.D.:3.91

This question focused on the applications and calculations relating to the concept of dynamic chemical equilibrium, including some aspects of aqueous equilibrium. Candidates were asked to state and apply Le Chatelier's principle and perform basic calculations involving equilibrium constants.

Candidates' performance on this question was satisfactory. The majority of candidates were able to state and apply Le Chatelier's Principle, however, some found it challenging to calculate K_p from the information given.

Some candidates also had problems calculating the pH of a solution of $Ba(OH)_2$. Many of them failed to account for two moles of hydroxide for every mole of $Ba(OH)_2$ in solution.

Question 6

Specific Objectives: 1.1, 1.2, 4.6, 6.5
Mean: 3.40; S.D.: 3.21

Performance on this question was generally poor as many candidates failed to gain marks on the definition of "electronegativity". Their definitions were either poorly or ambiguously worded. In many cases, electron affinity was confused with electronegativity. More practice is needed on precisely worded definitions which fully encapsulate the required terms.

Candidates also had difficulties distinguishing between structure and bonding and frequently confused the two. In addition, several confused the behaviour of the oxides with that of the chlorides. Candidates' responses suggested a piecemeal approach to learning the trends across the periodic table.

It is recommended that candidates practise to relate the properties of the elements to their electronic configuration so that the behaviour patterns of the elements can be cemented in their minds.

Paper 03/2 - (Alternate To Internal Assessment)

Question 1

Mean: 6.23; S.D.: 3.27

This question was designed to test candidates' ability to

- (i) use a burette properly
- (ii) record burette readings accurately to two decimal places
- (iii) use the most consistent readings to perform various calculations
- (iv) appreciate the suitability of an indicator.

The majority of candidates were unable to isolate the salient points and therefore failed to earn most of the marks awarded for the question. It was evident that a number of candidates did not possess the required knowledge and experiences to successfully manage the question. In some cases, candidates were unable to write the equation for the reaction.

In general, candidates did not score highly. This was due to failure on their part to

(i) perform molar calculations

(ii) manipulate titrimetric data (finding the average titre volume from the most consistent burette readings)

(iii) perform calculations to determine concentration.

It is recommended that more attention be given to molar calculations, choice of indicator and the correct use of the burette.

Question 2

Mean: 9.58; S.D.: 3.14

This question was designed to test the ability of candidates to

(i) read and record data from a syringe
(ii) plot and label a graph displaying recorded values
(iii) interpret the results illustrated by the graph
(iv) calculate the gradient at several points along a curve.

While the majority of the candidates were able to construct a suitable table to display the data and plot a proper graph, some candidates were confused as to which data were to be displayed on the axes. Some candidates plotted values of 1/t but labelled the axis as t in error. Other errors associated with plotting the graph included using an inappropriate scale and not using the tangent to the curve at particular points to calculate the gradient.

Overall, this question was not well done. Candidates need to pay particular attention to the reading of data from various pieces of apparatus and the recording of values in a table. It is also recommended that the drawing of graphs be practised.

Question 3

Mean: 4.96; S.D.: 2.44

This question investigated the ability of candidates to plan and design an experiment when given a scenario which required a chemical investigation.

Most candidates were able to state clearly a suitable hypothesis and a well defined aim. Most, however, failed to write a clear procedure for the designed experiment and were unsure as to the apparatus to be used. Many of them confused 'calorimeter' with 'colorimeter'.

UNIT 2

Paper 02

Question 1

Specific Objectives: 2.14, 2.15, 2.18, 3.2
Mean: 3.60; S.D.: 3.11

Candidates were required to demonstrate an understanding of the reactions of a number of functional groups and their associated reaction mechanisms.

In Part (a), most candidates correctly identified the intermediate X as nitrobenzene. However, the temperature at which the conversion occurs was not known by many. Candidates need to pay particular attention to the use of concentrated or dilute reagents and to state this information where appropriate in each case.

Question 2

Specific Objectives: 2.1, 2.2, 2.3, 2.4, 2.5
Mean: 4.52; S.D.: 3.09

This question examined the candidates' knowledge of

(i) the difference between end point and equivalence points
(ii) redox titrations and preparation of a standard solution
(iii) calculations associated with a back titration.

Surprisingly, many candidates were unable to define the terms 'equivalence point' and 'end point'. This is perhaps an indication that more care is needed to distinguish between the two as they relate to titrimetric analysis.

Most candidates were able to write the equation for the precipitation of barium ions and calculate the number of moles of $BaCl_2$ used for the reaction. Common errors included the elimination of state symbols which are important when writing an equation to show precipitation. Many candidates also found it difficult to balance the sodium ions in the equation.

The back titration continues to be challenging perhaps because so many candidates continue to find the mole concept to be a difficult area of chemistry. Teachers are encouraged to have mole concept workshops for their student where they can spend extra time to explain the concepts and engage them in adequate exercises to develop their confidence and ability. Too many candidates seemed unfamiliar with the experiment requiring oxalic acid to standardize a solution of potassium permanganate (VII). This may be an indication that some candidates are not exposed to a wide variety of laboratory experiments.

Question 3

Specific Objectives: 2.1, 9.7
Mean: 7.66; S.D.: 2.58

This question addressed the nitrogen cycle and the bauxite process and was attempted by most candidates. Marks were lost mainly through the omission of relevant information or incomplete definitions.

It is recommended that more emphasis be placed on the use of appropriate chemical terms when describing processes, colours, precipitates and other chemically related items.

Question 4

Specific Objectives: 1.8, 1.9, 3.2, 3.3, 4.2, 4.3
Mean: 6.88; S.D.: 3.83

This question focused on isomerism. As with most of the other questions, candidates have a problem with providing precise definitions even when it is clear from the examples given that they have an idea of the concept. Many, for example, were able to identify a chiral centre but were unable to give a definition.

Too many candidates were unclear about displayed structural formulae and condensed structural formulae. Teachers need to remind their students to make the distinctions. Some candidates lost marks for incomplete equations and an inability to name the amide link.

Question 5

Specific Objectives: 6.1, 6.2, 6.4, 9.3
Mean: 6.33; S.D.: 2.98

This question tested candidates' knowledge of the

(i) origin of absorption in IR spectroscopy
(ii) deduction of the functional groups of specific organic compounds based on IR data
(iii) chemical principles, advantages and disadvantages of steam distillation.

The question was poorly done. The principles of IR spectroscopy were not understood. Candidates showed confusion regarding the modes of vibration and the changes that occur within a molecule when subjected to infrared radiation.

Candidates needed more practice in deducing functional groups from IR spectral data.

Question 6

Specific Objectives: 6.1, 6.2, 6.3, 6.4, 7.2
Mean: 5.82; S.D.: 3.96

This question focused on the chlor-alkali industry and the use of sulphur dioxide as a preservative. A few candidates managed to earn full marks on this question but most candidates performed poorly. Yet again, definitions proved to be a big challenge for many candidates. There was a tendency to give examples where categories were requested.

Candidates were unable to give the products of the electrolysis of brine and to write the relevant half equations. Some candidates even confused the terms oxidation and reduction. The role and behaviour of sulphur dioxide in food processing is a mystery for many candidates and is a topic that should be addressed.

Teachers are encouraged to provide ample exercises on redox processes relating to electrolysis.

Paper 03/2 - (Alternate To Internal Assessment)

Question 1

Mean: 10.31; S.D.: 3.77

Most parts of the question were well done. However, there were some areas that were not handled well. In Part (b), while most candidates were able to describe the colour of the heated solid, they demonstrated difficulty in describing its texture.

Candidates also had difficulty in interpreting what was required of them for the column indicated in Part (c), as some proceeded to find the average of the masses involved.

In Part (h), most candidates wrongly calculated the number of moles of anhydrous salt which combined with one mole of water. More attention needs to be placed on calculations relating to the mole concept.

Question 2

Mean: 8.31; S.D.: 3.72

While candidates were able to identify $KMnO_4$ as the indicator in the titration, some had difficulty in recording the colour changes involved in Part (a). It was expected that the colour change recorded would have been colourless to pink. It should also be noted that in many cases, the formula for the manganate ion was written as MnO_4 instead of MnO_4^-. Candidates are once again encouraged to pay more attention to details.

In Part (b), candidates seemed unaware that the oxalic acid solution needs to be heated before titration with $KMnO_4$. This may be an indication of the lack of actual practical experience.

Question 3

Mean: 5.33; S.D.: 2.74

This question related to the planning and design of an experiment. Parts (a), (b) and (c) were handled well by most of the candidates. The writing of aims and hypotheses seemed to be well understood. However, the 'Procedure' presented a bit of difficulty along with Part (h) where candidates were unable to identify source of errors and an assumption. The inability of candidates to write clear procedural instructions for an experiment may be related to a general inability to clearly express themselves. This problem may be addressed by the provision of more writing opportunities for candidates in preparation for the examinations.

Internal Assessment

Submissions

Most schools submitted the laboratory notebooks of five candidates requested for the IA samples. Please note that the computer generated printout **must** also be included with the samples, mark schemes and moderation sheet.

Appropriateness of Mark Schemes

In most cases, mark schemes served as a useful guide to the moderator. There were, however, quite a few cases where the mark schemes were either incomplete or contained irrelevant skills.

It must be noted that Observation/Recording/Reporting marks are classified under Analysis and Interpretation. These include the working out of mathematical problems, identifying sources of error and the writing of equations.

Some teachers are still experiencing great difficulty writing mark schemes for Planning and Design (P and D) experiments. This is partly due to the inappropriate P and D activities chosen – this will be addressed later.

The task of moderation would be made more efficient if teachers included the identities of the unknowns involved and a copy of the table containing the accepted observations and conclusions for the qualitative analysis assignments. Also, where more than one mark is allocated for a particular skill, this should be broken down to indicate where each mark is awarded.
Teachers should be careful to award an appropriate number of marks for each response required, that is, the 'overweighting' of a skill should be avoided, (for example, the awarding of three marks for finding the average of three numbers is unacceptable).

Syllabus Coverage, Adequacy and Standard of Activities.

For most centres, the syllabus coverage and adequacy of number of activities were good. However, more effort should be made to spread the activities more evenly over the topics. For example, exercises in energetics, reaction rates and equilibrium should be included as well as the usually well represented exercises in volumetric and qualitative analysis.

More creativity needs to be exhibited in the assignments involving volumetric analysis so as to make them more challenging and appropriate to the CAPE level.

The Assessment of Skills

Most teachers did assess each of the four skills at least twice. Teachers must select only two of any skill for submission to CXC. These should be clearly indicated on the mark scheme and also in 'The Table of Contents' of candidates' laboratory notebooks. Candidates should be tested in SBAs on practical work with which they are familiar, bearing in mind that the SBA is a form of continuous assessment. Best practice would therefore dictate that candidates have prior experience in the various skills before any assessment is attempted.

Observation/Recording/Reporting (ORR)

Many teachers assessed this skill in a satisfactory manner. While the CXC mandate to assess communication, grammar, spelling and punctuation should be recognized, the testing of the observation of colours and precipitates, and the drawing of proper graphs and tables remain paramount.

More care needs to given to avoid wrong criteria being assessed under this skill, for example, discussion and calculation. Tables should be enclosed and have relevant titles and headings.
There has been an improvement in the number and the standard of graphs that were drawn.

Manipulation and Measurement (MM)

Though not moderated, evidence of this activity was examined in the samples. Evidence of TWO assessed practicals must be included in the candidates' laboratory notebooks. There should be an attempt to ensure variety in the measurements required in the assignments for the testing of this skill. These practicals should be included in the candidates' book and corrected, so that candidates may benefit from the appropriate feedback.

Analysis and Interpretation (A&I)

Activities testing this skill must be more challenging. Many calculations were too easy. In some cases, there was not enough evidence of individual work. Teachers should insist on deductions from observations/results in a progressive manner, and well balanced ionic and/or other equations with state symbols where applicable in the inorganic chemistry/qualitative analysis and physical chemistry. Analysis of graphs and discussion of results should be encouraged. **It is also important for teachers to remember that the drawing of graphs is an ORR activity and not an A&I.**

In volumetric analysis, the calculation of the average titre should involve the use of ONLY the closest values (no more than a difference of +/- 0.10 cm^3).

Planning and Designing (P& D)

The representation of this skill is still problematic. Again, it must be stressed that teachers need to be aware of and be able to apply the appropriate criteria in assigning activities for the testing of these skills. This is imperative in the setting of appropriate P and D exercises and allow for ALL the components of P and D – variables, method, expected results etc. – to be tested.

The assignments should be clearly written in both the candidates' books and mark schemes. Explicit information regarding the aim, method or the apparatus required should not be disclosed as these form an integral part of the planning and design exercise.

Planning and designing activities that can be taken from a text book are unsuitable. Teachers and candidates should resist the temptation to predict ACTUAL RESULTS. It should also be noted that there are some types of practicals that do not lend themselves to P and Ds.

A short excerpt from the Schools Report for the year 2008 is now reproduced to provide a sense of emphasis and urgency:

"Acceptable activities for P and D 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 text books.

Candidates should be instructed not to include actual results in their prediction of results.

A **sample Mark Scheme** for the assessment of P and D assignments is reproduced for guidance:

1. Statement of hypothesis — 3

    - Clearly stated and linked to the problem (2)
    - Clearly stated but partially linked to problem (1)
    - Not clearly stated but related to problem (1)

2. Aim/Title — 1

    - Must be relevant to the problem/hypothesis

3. Apparatus and Material — 3

    - Essential ones mentioned

4. Method/Procedure — 8

    (a) Plan written in logical sequence of steps and in appropriate language (3)

    - All steps written but no order, correct tense (2)
    - All steps written, no order, wrong tense (1)
    - Essential step(s) missing (0)

    (b) Variables (3)

    - Manipulated (1)
    - Controlled (1)
    - Responding (1)

(c) Data to be collected (2)

5. Predicted Results 3

- Correctly linked to problem/hypothesis (3)
- Not properly linked but correct (2)
- Not linked but correct (1)

6. Limitation, Sources of Error and Assumptions 2

- Limitation and sources of error (2)
- Assumptions made (1)

Total **20**

Conclusion

CAPE Chemistry continues to pose a challenge for too many candidates. This may be the result of several factors. It must be stressed, however, that many candidates are unable to express themselves clearly and to provide appropriate definitions of chemical terms and concepts. Candidates continue to use atoms, molecules, compounds and electrons interchangeably. There is a lack of attention to detail and this is evident especially where definitions of terms are required. In many cases, candidates are able to use the concept to do calculations, for example, to arrive at the appropriate answer, but when asked to define the concepts they are not able to earn the marks because of incorrect terminology and omission of pertinent details. It is suggested that candidates be given more opportunities to express chemical concepts in writing and to prepare adequately for the examination.