CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION MAY/JUNE 2007

CHEMISTRY

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GENERAL COMMENTS

The examination this year marks a transition from the original format to that predicated by the recent syllabus review which saw a realignment of modules and a streamlining of examination papers with the introduction of Multiple Choice papers.

The syllabus review of 2007/2008 resulted in the following changes:

Unit 1

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

Unit 2

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

The examination, therefore, consisted of Paper 01 in both Units being a Multiple Choice paper consisting of 45 items for 90 minutes. Paper 02 of Unit 1 tested candidates on the revised syllabus using an examination of six compulsory questions – half of the questions being of the structured form and the remainder of the structured free response (essay) type. Each question had a maximum mark of 15 – the paper, therefore, having 90 as its maximum mark. Paper 02 of Unit 2 used the original examination format of nine questions testing the original syllabus content.

This year saw a total of 3 575 registered candidates for the Unit 1 – this is an increase of 42.2 percent over the previous year where 2 513 candidates taking the examination. In Unit 2 the figures revealed a 60.5 percent increase – the totals being 1 701 for the present year as compared with 1,060 for the year 2006.

The overall performance showed an exceptional improvement over previous years in both Units.

DETAILED COMMENTS

UNIT 1

PAPER 01

Performance on this paper was good. Candidates were able to answer most of the questions correctly. Candidate performance on four questions could have been better. These questions assessed -

- the values of the bond angles in the displayed formula of the amino acid, glycine;

- factors affecting the solubility product of iron (III) hydroxide;

- the constituents of a standard hydrogen electrode;
- the reagent used to identify a compound, $X^{2+}(aq)$, given the reaction of $X^{2+}(aq)$ with aqueous NaOH, and aqueous NH_3.

PAPER 02

Question 1

Candidates were expected to demonstrate their knowledge of the principles of thermochemistry in the calculation of enthalpy changes, as well as, showing familiarity with simple experimental procedures.

Candidate performance was generally weak. While candidates were able to sketch the relevant energy profile diagrams and show an appreciation of the practical aspects of the subject, quite a few found difficulty with the calculations and the graphical representation of the experimental results as required in Parts (a), (b) (ii) and (b) (iv).

This weakness in the area of mathematical calculations became quite pervasive as the results of the rest of the paper unfolded.

Question 2

This question sought to test the candidates' understanding of some aspects of acid/base equilibrium.

Candidate response was generally satisfactory; marks were lost due to misconceptions such as -

- confusion of pH and pOH in the calculations in Parts (b) (ii) and (b) (iii);
- assumption that [acid] = $[H^+]$ in the case of weak acids – Part (b) (iii);
- use of the equation V = 1/conc. in the calculation in Part (b) (iii);
- confusing the notion of buffering and neutralization in Part (c).

Question 3

This question tested the candidates' knowledge of the chemistry of the Group II elements. Candidates' responses were disappointing with only a satisfactory performance being attained. While a number of candidates gained high marks for Parts (a) and (d), these areas presented challenges for many others.

One area of weakness was noticed in the responses for Part (b), where difficulty was encountered in the use of the correct technical terms to describe the relationships requested. It was disconcerting to note that quite a few candidates wrote Ba(OH), $Ba(OH_2)$ and $CaNO_3$ as the formulae for barium hydroxide and calcium nitrate (V) respectively. Some candidates were also unaware of the alkaline nature of barium oxide and assumed the brown gas in Part (b) to be bromine.

Question 4

This question required candidates to be able to show understanding of the concept of "ideal" and "non ideal" with respect to the theory of gases.

Candidate performance on this question was inconsistent. Marks were lost in the writing of the equation to represent the decomposition of sodium azide, Part (a) (iv), and the factors responsible for gaseous behaviour deviating from ideality, Part (b) (ii).

Question 5

Candidates were asked to demonstrate their competence in answering questions relating to kinetics and the use of initial rates data in deducing properties of reactions.

Candidates' grasp of this part of the syllabus was only satisfactory. The concept of half-life was clearly unknown to candidates and hence its calculation in Part (b) (iii) could not be performed. Challenges encountered by candidates included -

- the notion of "effective collisions" and its vital influence in determining reaction rates, Parts (a) (ii) and (b) (iv);
- the interpretation of equilibrium constant for rate constant with the resultant loss of marks in Part (b) (ii).

Teachers need to pay some attention in teaching the collision theory, and the relation and distinction of equilibrium and rate constants.

Question 6

This question dealt with the roles of oxygen and carbon monoxide as ligands in the complexing of haemoglobin in the human vascular system, as well as, the origin of colour in transition metal complexes.

This question produced only a very modest performance. While candidates were comfortable in identifying the ligands requested in Part (a) (i), and explaining the toxic effects of high concentration of carbon monoxide in Part (b) (ii), most candidates found extreme difficulty in accounting for the colour in transition metal complexes in Part (c), and failed to distinguish between redox and ligand exchange in answering Part (a) (ii).

It is clear that teachers need to review their strategies for teaching the above aspects of transition metal chemistry.

UNIT 2

PAPER 01

Candidate performance on this Multiple Choice paper was good. Areas which provided some challenge to the candidates were:

- indicators which produce a sharp colour change in the titration of a strong acid against a strong base;
- K_{sp};
- the metallic character of Group IV elements;

- a commercial method of alcohol production;
- reactions in catalytic converters;
- nitrogen fertilizers for plant growth;
- formation of photochemical smog.

PAPER 02

It is to be noted that this paper used the original format of the examination – the three compulsory items in Section A, having a maximum mark of 30, while the three questions chosen from the six in Section B had a maximum mark of 60.

Question 1

This question focused on the concept of equilibrium constant, its calculation and an appreciation of the practical details associated with its determination. Candidates' performance on this question was inconsistent. The main difficulties experienced were:

- the writing of the equation in Part (a) (i), where many candidates indicated that bromine was monatomic;
- the writing of the expression for K_c, Part (a) (ii);
- the failure to appreciate that accurate results come from accurate analysis. Most candidates offered the response "closed system" as the answer in Part (b) (ii).

Candidates should be encouraged to use reversible arrows to indicate a chemical equilibrium system.

Question 2

This question centred on some aspects of the chemistry of the sodium halides and elemental chlorine. Candidates' responses were disappointingly weak. While candidates were able to get credit in a few areas, most were unable to show mastery of the content required. Candidates lost marks by their inability to:

- write correct formulae and hence to produce the balanced equation required in Part (c);
- calculate oxidation states (this included failure to recognize the oxidation states of elemental substances to be zero);
- calculate changes in oxidation states;
- identify the foul odor of H_2S in Part (a) (v).

Question 3

This question tested the candidates' knowledge of the effects of industrial pollution and the interpretation and use of calibration curves.

Candidates found this question to be very easy and almost all candidates did very well. The only difficulty encountered involved confusing the process of eutrophication in Part (a) (iii) with an observable outcome, algal bloom, in Part (a) (ii).

Question 4

Candidates' knowledge of buffer systems and, in particular, the control of blood pH by the H_2CO_3/HCO_3 system, along with numerical calculations was the focus of this question.

Candidates showed variable performance levels. Some candidates are to be commended for providing very sound answers. Difficulties were experienced in explaining the working of the buffer system as it related to the effects of strenuous exercise and deep breathing in Part (c). Candidates' responses should have included:

- the equilibrium shifts to produce H_2CO_3;
- H_2CO_3 dissociates to increase H^+ concentration in the blood;
- deep rapid breathing cleans the lungs of $CO_{2(g)}$;
- equilibrium will shift to the left to release CO_2 from the blood;
- H^+ ions reabsorbed as equilibrium shifts to the left.

Question 5

This question probed the candidates' knowledge of reaction kinetics using the alkaline hydrolysis of a halogenoalkane, as well as their understanding of the collision model.

In general, candidates' responses were good with most candidates showing a reasonably satisfactory grasp of the concepts involved.

Some weakness was shown in explaining the mechanism of an S_N2 reaction and the importance of the concept of "effective collisions" as it pertained to reaction rates.

Question 6

Candidate performance was just about satisfactory in this question which dealt with the chemistry of the oxides and chlorides of Period 3. Candidates gained marks in Parts (a), (b) and parts of (c). Areas of weakness included:

- the writing of equations, for example, the reaction of phosphorus (V) chloride and water;
- the lack of awareness of the influence of both covalent and ionic character in $A1C1_3$;
- the difficulty in distinguishing between "intra" and "inter" molecular bonds with the view being expressed that "covalent bonds are weak";
- confusion resulting from a failure to carefully distinguish between structure and bonding in Part (e).

Question 7

This question tested candidates' knowledge of the chemistry of the Group IV elements and was slightly less popular than Question 6.

Performance on this question varied. Candidates were able to describe the trend in electrical conductivities of the elements in relation to their physical structure and were aware of the simple

covalent bonding of carbon dioxide. The majority could also classify the acid/base character of the Group IV dioxides.

However, challenges were experienced in the -

- use of standard electrode potentials in commenting on the relative stability of the +2 and +4 oxidation states of the elements in Part (d), and the oxidizing strengths of Sn^{2+} and Pb^{2+} in Part (e);

- failure to recognize the availability of empty "d" orbitals on the silicon atom as the reason for the observations presented in Part (f).

Question 8

This question tested the candidates' knowledge of the crude oil industry and its impact on the environment, and produced a rather weak performance. Candidates could state the name of the process used to separate the crude oil into its various components as well as some of the environmental implications of the use of fossil fuels.

Candidates were, however, very unsure about the underlying basis of the process of fractional distillation (fractions are separated according to boiling point or higher molecular mass fractions at the bottom, lower molecular mass fractions at the top of the fractionating tower).

Candidates again found the writing of equations difficult and were surprisingly unable to explain the source of lead (II) oxide in vehicular exhaust as the result of the reactions produced by the additive tetraethyllead (IV).

Question 9

This question was the overwhelming favourite of this final pair. It required candidates to answer questions concerning the:

- preservation of ozone levels as well as its polluting effects in the environment;

- use and destructive effect of CFCs on the environment.

The performance demonstrated a satisfactory grasp of the knowledge required. The main difficulty revolved around the roles played by stratospheric and tropospheric ozone.

PAPER 03

INTERNAL ASSESSMENT

This year saw an overall improvement in the level of the attainment on this component of the examination. However, giving allowances for the introduction of new Centres, there are some unacceptable trends that seem to have become endemic.

Most Centres submitted the required number of samples with the accompanying mark schemes that were satisfactory. However, quite a number of samples were incomplete or had activities classified incorrectly. Teachers are again reminded that the writing of equations and the performance of

calculations are Analysis and Interpretation (A/I), and **not** Observation/Recording/Reporting (O/R/R) skills.

Great difficulty continues to be experienced in the writing of appropriate mark schemes for Planning and Design (P/D) experiments. This is mainly due to the inappropriateness of the activities. Teachers are also encouraged to include the identities of the various unknown substances used in qualitative analysis assignments, as moderation is difficult when the identities of the substances must be deduced.

Syllabus Coverage

The coverage of the syllabus and the number of activities were good. There needs to be an improved attempt to provide a more even spread of the activities over the various topics. An example of the above involves the use of five volumetric or qualitative analyses, one energetics and the absence of an equilibrium activity.

It would be desirable if more creativity was demonstrated in making the volumetric and kinetic experiments more challenging to students at this level.

The Assessment of Skills

Most teachers did assess each of the four skills at least twice as required. However, some Centres assessed one or two skills in every one of, as much as, 17 assignments! While the various skills may be tested on a large number of occasions, teachers must indicate by an asterisk the two or at most three assignments used in the determining of the mark to be submitted for moderation.

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

This skill was assessed in a satisfactory manner in many Centres. In a few, the traditional activities used to assess this skill – observation of colour and formation of precipitates, drawing of graphs, production of tables – were neglected so that the assessment of communication skills could not be made. The assessment of these two areas is to be inclusive in the overall assessment of this skill. More use of graphs needs to be made in the selection of activities. Teachers are reminded that the skills associated with the plotting of points and the drawing of graphs are O/R/R and **not** A/I skills.

Manipulation and Measurement (M/M)

Though not moderated, evidence of the assessment of this skill was examined. Once again indication of at least two assessed experiments must be indicated and the marks noted in the laboratory books. Activities that discriminate adequately between the abilities of candidates should be used.

Analysis and Interpretation (A/I)

Activities used to test this skill need to be more challenging. Many calculations were too easy. Teachers should ensure that calculations should involve between four or five steps so that candidates would be challenged to show the reasoning behind the attainment of the answers (this would also tend to lessen the incidence of cheating).

In the case of qualitative analysis activities, deductions should be based on observations made in a logically progressive manner and well balanced ionic and/or molecular equations required to represent the various reactions involved. Analysis and Interpretation of graphs with the use of results should be encouraged bearing in mind the concluding statement made in the discussion of O/R/R above.

Planning and Design (P/D)

This skill continues to provide the greatest concern to moderators with the inappropriateness of the assignments becoming endemic. Teachers are reminded that acceptable activities for P/D should pose a problem for students to solve using concepts contained in the syllabus. These problems should encourage hypothesis-making, be contextualized in "novel" situations and should not be a repetition of activities previously done or readily available in text books.

Actual results should not be included in the "expected results" component of the reporting.

SUMMARY

The greatly improved candidate performance is noted. Performance can be further improved if teachers devise new strategies or refine present ones to address the following candidate weaknesses:

- difficulty in the use of technical language to describe/explain various chemical phenomena;
- the ability to manipulate mathematical formulae and the working out of calculations with associated units;
- the writing of correct formulae and the balancing of equations, with relevant state symbols, to represent chemical reactions.