CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION MAY/JUNE 2006

CHEMISTRY

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CARIBBEAN ADVANCED PROFICIENCY EXAMINATIONS

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DETAILED COMMENTS

Unit 1
Paper 01

Question 1

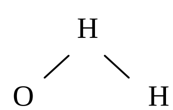
This question sought to test candidate’s comprehension of the principles and processes of radioactive decay, the use of mass spectral data and the shapes of atomic orbitals.

Candidates’ responses were generally satisfactory. However, a significant number found the representation of a **â** particle and hence the writing of the resulting nuclear equation a distinct challenge. A common mistake involved the writing of the titanium atom as

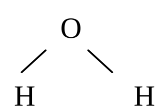
$^{51}_{23}Ti$ instead of $^{51}_{22}Ti$.

Question 2

Candidates were required to demonstrate their understanding of the forces of attraction between particles and their influence on the properties of matter.
While many candidates showed an adequate grasp of the information required, a large number found difficulty in describing the relevant aspects of the VSEPR model and its subsequent application to the compounds specified.
Candidates used “crooked” to describe the shape of the H_2S molecule and depicted the water molecule as



instead of



Question 3

This question, which tested the candidates’ comprehension of the principles involved in energy changes and the associated calculations, produced inadequate responses. Candidates showed weaknesses in defining the required terms, and in accurately expressing their thoughts. Most candidates were unaware that the enthalpy of solution requires the substance to be dissolved in an excess of solvent.

The calculation in (b)(ii) was poorly done reflecting the difficulty with the energetics of the process of dissolution. (See Appendix A)

Question 4

This question focused on the areas of functional groups and their chemical reactions. The performance of candidates was very weak. While candidates demonstrated little difficulty identifying the esterification reaction as involving ethanol and the carboxyl group, difficulties were evident in the

- differentiating between amide and amine,
- need for the presence of concentrated sulphuric acid as distinct from sulphuric acid in the esterification process,
- the use of $SOCl_2$ in the replacement of –OH by –Cl inorganic molecules.

Question 5

In this question candidates were required to demonstrate an understanding of the structure and formula of organic molecules with particular reference to the concept of isomerism.
The performance of candidates was satisfactory. However, significant difficulty was shown in distinguishing the various forms of structural isomers. Some uncertainty was also shown in the writing of full structural (displayed) formulae as distinct from condensed forms.
Most candidates were able to identify and write the formulae of the optical isomers.

Question 6.

This question tested knowledge of the process of polymerization.

Performance was inconsistent. While some candidates produced good responses, a large number found the question challenging. Difficulty was encountered in the comprehension of the differences between

- hydrolysis and hydration,
- amide and amine groups.

Question 7

Candidates showed commendable performance in answering this question which focused on the notion of primary standards and the calculations based on titrimetric analysis. Some candidates clearly misread Part (b), giving responses relating to the actual titration rather than the preparation of the standard solution.

Question 8

This question, dealing with chromatography as a separating technique, was generally adequately done by the candidates.

The main difficulty encountered involved the difficulty in the explanation of the difference between the terms “stationary” and “mobile” phase.

Question 9

This question sought to test the candidates' understanding of the basic concepts of IR spectroscopy. Candidates' responses indicated that this aspect of the course was not well understood. Candidates were generally unaware that IR activity must involve vibrations that result in a change of dipole moment and of the need to use IR inactive material for the essential components of the IR spectrophotometer.

Unit 1
Paper 02

Question 1

This question centered around the use of combustion analysis for the determining of empirical and molecular formulae.

Candidates showed a commendable level of proficiency in answering this question, handling the calculations with relative ease. However, many candidates disregarded the instructions to describe the observations associated with the tests for water and carbon dioxide. Many candidates responded by simply giving the reagent, "cobalt chloride paper turns pink" instead of "cobalt chloride paper turns from blue to pink", and "anhydrous copper sulphate turns blue" instead of "anhydrous copper sulphate goes from white to blue".

Question 2

In this question candidates were asked to demonstrate their understanding of functional group analysis. While most candidates demonstrated a familiarity with the various reactions of the functional groups, the application of this knowledge in (a)(vi) and (b) (iv) presented some difficulty.

Candidates should be able to demonstrate these skills at this level.

Question 3

This question, which dealt with purification techniques was poorly answered. Most candidates appeared to be unsure in dealing with the flow chart. Filter paper is not considered a piece of laboratory equipment.

Question

There was a general inconsistency in the performance of candidates on this question which focused on the basic ideas of chemical equilibrium.

Candidates were generally comfortable with the description of the characteristic properties of a chemical equilibrium and simple equations as requested in (a)(i) – (iii) and (b)(i).

Candidates, however, surprisingly found the calculations of initial and equilibrium concentrations (which involved manipulations of moles) difficult. Others confused the use of square [ ], and curved ( ) brackets, the latter to be used to express partial pressures.
(seen Appendix B)

Question 5

This question tested the candidates' familiarity with the concepts of redox reactions, their ability to manipulate oxidation numbers and the writing of redox equations.

The general standard of proficiency in this area was weak. The writing of equations continue to be a source of difficulty.

Question 6

Candidate performance on this question was particularly weak.

While the responses regarding homolytic bond fission were good, the areas of identification and explanation of reaction mechanisms presented great difficulty. Most candidates found the use of arrows in this context to be quite bewildering. A common error involved the use of arrows to indicate the movement of charge instead of the movement of a pair of electrons. Candidates also seemed not to be aware that the inductive effect operates through **ó** bonds resulting in a redistribution of charge caused by electronegativity differences.

Question 7

This question was centered around the concept of acidity /alkalinity of organic compounds.

Candidate performance was inconsistent. The main area of difficulty involved the ability to explain concisely the difference in alkalinity of the given molecules. Candidates were generally aware that alkalinity depended on the availability of the lone pair on the nitrogen atom. However, the factors which influenced this availability presented great difficulty.

The subsequent question involving evaluation skills in Part (c) proved to be quite challenging.

Question 8

This question concerned knowledge in the area of the syllabus referring to “Uncertainty in measurement”.

Over ninety per cent of the candidates chose this question. Performance was generally satisfactory. Part (b)(ii), instrument calibration, presented a challenge for a number of candidates.

Question 9

This question sought to discover the candidates’ understanding of phase separation with respect to distillation and its application.

Responses were weak, although the construction of the boiling point/composition curve produced quite good efforts. Candidates did find parts of the question requiring explanation and application of principles challenging.

Unit 2
Paper 01

Question 1

This question focused on the concepts of solubility product and common ion effect and the associated calculations.
Candidates demonstrated a satisfactory level of comprehension in these areas of knowledge.
Candidates also dealt adequately with Part (b) involving the calculation the of PbCl, most arriving at the correct answer of $0.25\ x\ (0.050) = 0.0000625\, mol^{-3}\ dm^{-9}$.

Question 2

This question tested the candidates’ understanding of the various aspects of acid/base equilibria.

Question 3

This question required candidates to demonstrate their knowledge of the principles of redox equilibrium.

Candidates were able to produce a labeled diagram for the determination of the standard electrode potential of the $Zn^{2+}(aq)/Zn(s)$ electrode. However, responses to Part (b)(iii), which dealt with the relationship between cell e.m.f. and concentration, were vague and somewhat confusing.

Question 4

This question sought to test the candidates' knowledge of the chemistry of the Group II elements.

Candidate performance was generally good. Most candidates were able to explain the trends in 1st. ionization energy, write equations for the elements' reaction with water and gain at least two marks in the explanation of the variation of the solubility of the sulphates. Candidates showed little awareness of the fact that

- the 1st. ionization energy involved a gaseous reaction

$$Be(g) \rightarrow Be^{+}(g) + e^{-}\text{, and} \quad K_{sp}$$

- the charge/radius ratio of the Group II cations was vital to the decline in the value of the hydration energy with the resultant reduction of the solubility of their sulphates.

Question 5

Candidates were required to demonstrate a knowledge of the reaction of specific ions.

The performance on this question showed some inconsistency. Candidates demonstrated some knowledge of the reaction of the relevant ions. However, the failure to write the formulae of the ions rather than the symbols of their elements Part (a), and the difficulty in writing ionic equations , Part (b)(iii), gave rise to the above inconsistent performance.

Question 6

A knowledge and understanding of aspects of the chemistry of the transition elements were required for this question.

Candidates produced a commendable performance in this question. Candidates' responses to Parts (a) – (c) were generally good. However, most responses for Part (d) were disappointing. The notion that high charge density of the chromium ion results in the loss of hydrogen ions from the hydrated ion, $[Cr(H_2O)_6]^{3+}$ thus producing acidic solutions was not generally appreciated. The equation showing the dissociation was almost unknown.

$$[Cr(H_2O)_6]^{3+}(aq) + H_2O\,(l) \rightleftharpoons H_3O^{+}(aq) + [Cr(H_2O)_5OH]^{2+}(s)$$

Question 7

This question focused on the processes involving the production of aluminium from its ore.

Candidates were quite knowledgeable in this area of the course as attested by their responses. This was somewhat spoilt by the laxness in specifying the need for a high *electrical* energy input, while the calculation in Part (c)(i) was a challenge to some candidates. (See Appendix D).

Question 8

This question dealt with the importance of halogen compounds in the form of CFCs and the environmental consequences of their use with reference to ozone interaction.

Candidates' performance was generally good. Some difficulty was encountered in using the relevant equations in responding to the questions asked.

Question 9

This question tested the candidates' understanding of the consequences of altering the concentration of the nitrogen oxides and carbon dioxide on the atmospheric environment.

Candidates demonstrated an adequate knowledge of the effects of the above changes. The responses given for Part (iv) tended to be vague. While candidates appreciated the fact that melting ice results in insufficient ice being present to make a surface crossing of the Artic Ocean, they did not understand the process which causes the ice to melt. Increased use of fossil fuels results in increased levels of CO_2 which absorbs IR radiation, leading to global warming and a melting of the ice caps.

Unit 2

Paper 02

Question 1

This question required candidates to be knowledgeable in the area of reaction kinetics.

Candidates generally demonstrated a poor grasp of the principles involved in this area of the course. Candidates failed to sketch the graph required in Part (b)(i), while the concept of order of reaction and its implications presented an unusually high degree of difficulty.
(See Appendix E).

Question 2

Candidates were tested on their knowledge of the chemistry of Group IV elements.

The performance on this question was inconsistent.
Some deficiencies were observed in the areas involving

- the writing of ionic equations
- the calculation of oxidation numbers (cf. ox. number of chlorine in NH_4ClO_4)

Question 3

This question focused on the manufacture and chemistry of ammonia. Candidates demonstrated some variability in performance, which was caused by the difficulty experienced in following the flow chart.

Question 4

Knowledge of the principles of chemical equilibrium was tested in this question.

Candidate performance was inconsistent. While most candidates were comfortable in the areas of defining and describing of the features and conditions of such systems, the area involving calculations as tested in Part (a)(iv) and (c) provided distinct challenges for most candidates. (See Appendix F)

Question 5

Knowledge of the principles and application of buffer systems and pH were examined in this question.

Candidate performance was rather weak. Candidates demonstrated difficulties in the application of these concepts as seen in their responses to questions dealing with the

- explanation of the role of amino acids as buffers in human blood, Part (c) (i)
- calculation of values of pH and K_a from the data provided, Part (d). (See Appendix G)

Question 6

This question which dealt with the chemistry of the Group IV elements was not popular with candidates.

Performance was rather weak. The best responses were found in Part (b) (ii), where most candidates were able to deduce the reducing property of substance P, and thus its role in the conversion of nitrobenzene to phenylamine.

Candidates demonstrated

- some degree of confusion in trying to explain the trends as indicated in Part (a),
- great difficulty in identifying the substances in (b)(i), although a large number recognized the reducing property of J, PbO_2 and the identity of L as oxygen.

Question 7

This question focused on the structure, bonding and chemistry of the elements in the Period Sodium to Argon as set out in the syllabus.

Candidate performance was satisfactory.
Candidates were able to describe the reaction of the elements specified with water, Part (b). However, deducing the structure and identity of the substances A to E proved to be a challenge .

Question 8

A knowledge of the environmental impact of solid waste as well as the process involved in its recycling were required for the answering of this question.

Candidates' performance was weak.
However, notice was taken of the difficulty experienced by candidates involving the

- confusion between depolymerisation and decomposition,
- suggestion of a suitable solvent for the process outlined in Part (c),
- evaluation of incineration as a method of disposal of PVC material. (This should be noted by teachers as indicating a lack of appreciation of chemical principles to this area of the course.)

Question 9

This question dealt with the refining of crude oil and the importance of its components to the petrochemical industry.

Candidates demonstrated an inadequate grasp of this area of knowledge as seen in the responses provided. Candidates found Part (a) and (b) particularly easy, but experienced some difficulty in Part (d).

INTERNAL ASSESSMENT

The level of performance on the Internal Assessment component of the examination was generally satisfactory.

Marking schemes

In most cases mark schemes were submitted and were very helpful. However, there were too many cases where these schemes were either incomplete or contained activities which were inconsistent with the skill being assessed.

Teachers are reminded that

- mathematical calculations and the writing of equations are to be assessed as Analysis and Interpretation (A&I) ***not*** Observation/ Recording/Reporting (O/R/R)skills
- the awarding of marks for the writing of experimental titles is inappropriate.
- while the assessing of student communication skills in the use of grammar, as mandated by the syllabus is to be commended, this is not to be at the expense of the fundamental O/R/R skills, for example, observations of colours and precipitates, recordings of accurate measurements, the drawing of appropriate graphs and tables.

Assessment of Skills

While most centres did assess each of the skills at least twice, some assessed one or two skills every time a practical exercise was done. This makes moderation extremely difficult as it leaves the moderator with the daunting task of determining which of these practicals were used to produce the data to be moderated.

Planning and Design

This area of assessment continues to present the most challenges.
There still exist the problem of the use of inappropriate activities for the testing of Planning and Design (P&D) skills.

Teachers are reminded that in choosing activities for the assessment of this skill, situations must be presented to students that allow for the formulation of valid hypotheses which will lead to the construction of plans with clear and identifiable variables.

Teachers should also encourage students to refrain from the prediction of actual results. Given the above, certain popular activities will be ruled inadmissible for the testing of this particular skill, such as, the identification of different classes of alcohols as a qualitative analytical exercise.

Appendix A

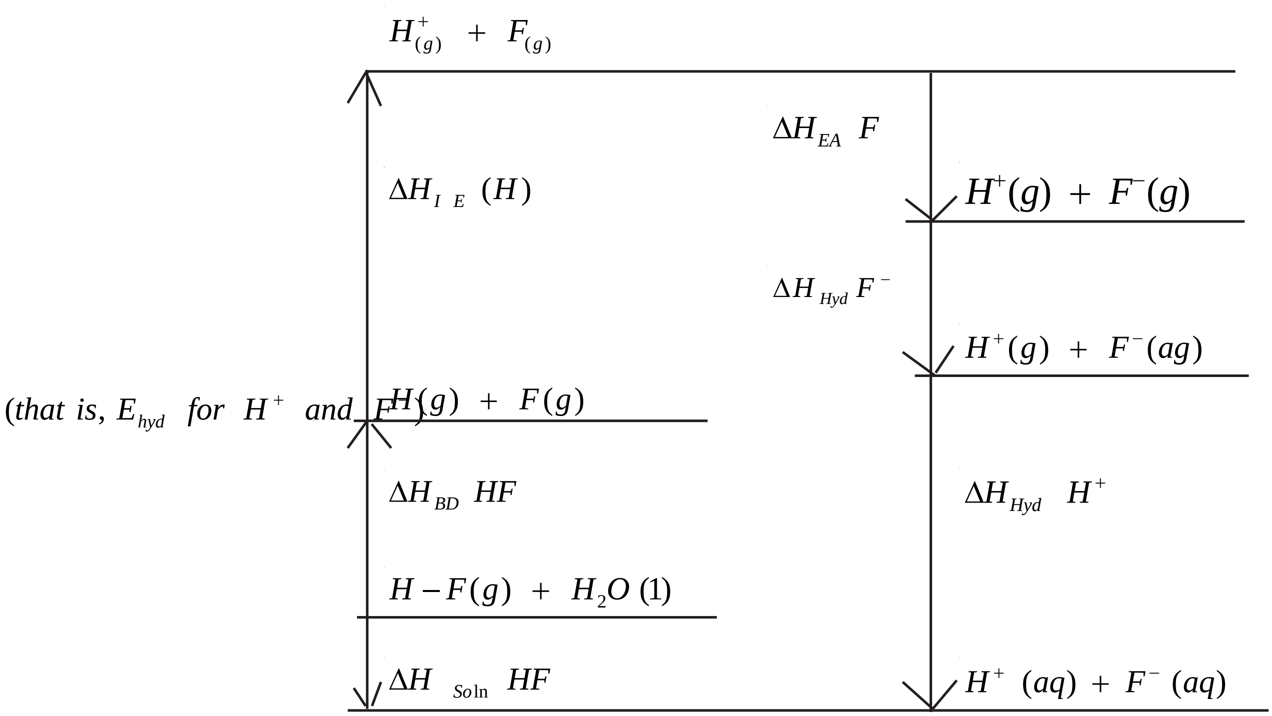
UNIT 1
Paper 01

Question 3

(a) The enthalpy change at 25^{0}C and 1 atm when one mole of solute is dissolved in a large excess of solvent until there is no further change.

(b) (i) Hess' Law: The standard enthalpy change for a reaction is independent of the route taken from reactants to products.

(ii)



$$\Delta H_{soln}\ HF = \Delta H_{BD+}\ \Delta H_{IE+}\ \Delta H_{EA} + \Delta H_{hyd}F^- + \Delta H_{hyd}H^+$$

= 562 + 1310 - 328 - 506 -1300
= -262 k J mol^{-1}

(iii) Bondmaking: exothermic; bond breaking: endothermic

$\Delta H_{soln}\ HF\ is\ -ve\ (exothermic)$

$\Rightarrow$ E absorbed in bond breaking < Energy released in bond making

Appendix B

Unit 1 Paper 02

Question 4(a)

(iv) a) No. of moles of hydrogen reacting
= 1 - 0.67
= 0.33

b) Equilibrium Conc. I_2 = 1.67 mol dm^{-3}
HI = 0.66 mol dm^{-3}

(v) $K_p = \dfrac{P^2_{HI}}{P_{H_2} P_{I_2}}$

Appendix C

Unit 2 Paper 01

Question 2

(c) pH = 2.4

$$\Rightarrow H^+ = 4 \ x \ 10^{-3} \ mol \ dm^{-3}$$

$$[H^+] = [HCOO^-]$$

$$K_a = \frac{(4 \ x \ 10^{-3})^2}{0.1} \qquad \text{Expression } K_a = \frac{[H^+]\,[HCOO^-]}{HCOOH}$$

$$= \frac{(16 \ x \ 10^{-6})}{0.1} \quad \text{mol dm}^{-3}$$

$$= 1.6 \ x \ 10^{-4} \quad \text{mol dm}^{-3}$$

Appendix D

UNIT 2
Paper 01

Question 7

(c) (i) $Al_2O_3(l) \rightarrow 2Al(l) + \frac{3}{2}O_{2\,(g)}$

$(54 \div 102) \; x \; 1900$
$= \; 1006 \; \text{kg}$

(ii) The extraction process is highly efficient

OR

Efficiency of the process is

$= \; 99\%$

Appendix E

UNIT 2
Paper 02

$\frac{1000}{1006} \; x \; 100\%$

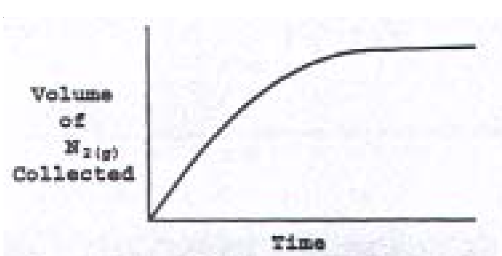
Question 1

(a) (i) Rate x 2 (doubles)
Reaction 1^{st} order w.r.t. $[H_2 \; (g)]$

(ii) Rate $x \; ^1\!/_4$
Reaction 2^{nd} order w.r.t. $[NO\,(g)]$

(iii) Rate x 27

(b) (i)



(ii) Pressure measurement

(iii) 1. Apparatus sealed

2. The volume of gas evolved must not exceed the maximum volume which could be held in the syringe (used for collecting and measuring the volume of gas).

Appendix F

UNIT 2
Paper 02

Question 4

(c) Initial partial pressure of $SO_2\ (g)$ = mole fraction x Total pressure
=2/3 x 5 = 3.33 atm

Initial partial pressure of O_2 (g) = 1/3 x 5 = 1.67 atm

For P_{so_3} to be 3 atm $\Rightarrow$ 3 atm of SO_2 (g) had reacted and 1.5 atm O_2 (g) had reacted using mole ratios from equation.

Partial pressure of gases at equilibrium:

$P_{0_2} = 1.67 - 1.5$

= 0.33 atm = 0.17 atm

$$\therefore K_p = \frac{(3)^2}{(0.33)^2\,(0.17)} = \frac{9}{0.0185} = 486.49\ atm^{-1}$$ or

If serial division done as

$$\frac{9}{0.33} = x;\ \frac{x}{0.33} = y;\ \frac{y}{0.17}$$

accept 486.14 atm^{-1}

Appendix G

UNIT 2
Paper 02

<u>Question 5</u>

(a) A buffer solution resists pH change on addition of small amounts of acid or alkali

(b) (i) To maintain a pH of 7

(ii) CO_3^{2-} reacts with excess H^+ ion

HCO_3 reacts with excess OH^- ion

(c) (i) Amino acids contain both acidic and basic groups

- NH_2 group can react with excess H^+ ion
- COOH group can react with excess OH^- ion

(ii) food processing

(d) (i) M_r of CH_3 $COONa = 82$

$6.56/82 = 0.08$ mol dm^{-3}

(ii) $$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

$$1.8\ x\ 10^{-5} = \frac{[H^+]\ x\ 0.08}{0.02}$$

$$[H^+] = \frac{1.8\ x\ 10^{-5}\ x\ 0.02}{0.08} = 4.5\ x\ 10^{6}\ mol\,dm^{-3}$$

$$pH = -\ \log\ 4.5\ x\ 10^{-6}$$

$= 5.3$

Assumption: The concentration of CH_3COO^- ions is equal to the concentration of CH_3COONa

(e) (i) Initial concentration of CH_3COONa = 0.08 mol $dm^{-3.}$
Concentration after adding = 0.08 + .005 NaOH

$$= 0.085 \; mol \;\; dm^{-3}$$

Initial concentration of CH_3COOH = 0.02 mol dm^3
Concentration after adding NaOH

= 0.02 - 0.005

= 0.015 mol dm^{-3}