CARIBBEAN EXAMINATIONS COUNCIL

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

MAY/JUNE 2014

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, some improvement was noted in performance in 2014 when compared with 2013. However, in both units, performance across the two papers continues to be disparate with the means on Paper 02 significantly lower than those on Paper 01.

As identified in 2013, some of the underlying causes for the poor performance on Paper 02 include

- the general absence of critical thinking skills
- the inability of candidates to operate beyond the basic level of comprehension
- challenges with questions involving the use of application, analysis and synthesis
- severe limitation in the use of technical language to explain chemical concepts and phenomena
- 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. However, Kinetics and Equilibria as well as qualitative and quantitative treatment of first-order equations (Module 2) continue to present challenges to too many candidates.

Paper 02 – Structured Essay Questions

Section A

Module 1: Fundamentals in Chemistry

<u>Question 1</u>

Syllabus Objectives: 3.1–3.9
Mean: 4.39; Standard Deviation: 3.44

This question sought to assess candidates’ understanding of the mole concept, associated calculations and practical applications.

Overall, candidate performance was surprisingly weak. Many candidates were unable to define the term *mole*, limiting the term to atoms only. In the case of *molar mass*, the majority of candidates was able to define the term. However, there is concern that too many candidates found it challenging to provide a simple definition and to state the associated unit of g mol^{-1}.

The majority of candidates was also unable to correctly perform the calculation for Part (b), and very few candidates were able to obtain the five marks allocated to Part (c).

Expected Responses:

(b) (i) a) The number of moles M_2CO_3:
Number of moles HCl:

1000 cm^3 contain 0.150 mole

$\therefore$ 23.6 cm^3 HCl contain $\frac{0.150 \text{ moles x } 23.6 \text{ cm}^3}{1000 \text{ cm}^3}$

= 0.00354 mole

Moles M_2CO_3 = ½ x 0.00354 mole
= 0.00177 mole

(i) b) The relative molecular mass of M_2CO_3:

1000 cm^3 of M_2CO_3 contain 6.125 g
$\therefore$ 40 cm^3 of M_2CO_3 contain 0.245 g
So, 0.00177 mole of M_2CO_3 weighs 0.245 g

$\therefore$1 mole of M_2CO_3 weighs $\frac{0.245 \text{ g x 1 mole}}{0.00177 \text{ mole}}$

= 138.418 g

(ii) M_2CO_3 = 138.42 g
M_2 + 60 g = 138.42 g
M_2 = (138.42 – 60)g = 78.42 g
M = 39.21
M is potassium, K.

(c) 6.125 g of M_2CO_3 are weighed on an analytical balance and made up to 1 dm^3 in a volumetric flask.
Two 20 cm^3 portions are pipetted into a conical flask and methyl orange is added.
The mixture is titrated with the hydrochloric acid until the yellow indicator changes to pale pink.
The volume of acid used is noted.

It is recommended that teachers

- impress upon students that the mole is a *universal unit* describing the 'amount of substance' containing the Avogadro Number of particles
- provide students with adequate practice in the use of relevant concepts in solving mathematical problems
- ensure students' *continued* exposure to performing titration exercises which would allow them to describe in detail the use of a pipette, burette and associated apparatus.

Module 2: Kinetics and Equilibria

Question 2

Syllabus Objectives: 1.5-1.7; 3.1-3.7
Mean: 5.75; Standard Deviation: 2.93

This question tested candidates' understanding of the

- Bronsted-Lowry concept of acids and bases
- use of the initial rate method in determining the order of reaction and applied deductions
- experimental description of determining rate of reaction.

The majority of candidates' responses was weak and inadequate. Candidates obtained marks from responses to Part (a) relating to the theory of acids and bases, as well to Part (c) dealing with calculations based on information involving initial reaction rates.

In Part (b), most candidates were unable to provide a correct sketch to show the changes taking place during the titration of equimolar solutions of hydrochloric acid and aqueous ammonia. Candidates were expected to indicate the volume at which the rapid change of pH occurs and to recognize that aqueous ammonia is a weak base hence the end/equivalence point would be at a pH less than seven.

Most responses to Part (d) were very poor. Very few candidates were able to describe an alternate method for determining the rate of reaction requested.

Once more, there is an obvious lack of familiarity with the practical application of chemical concepts. Teachers are reminded that investigation is a vital part of the subject and are encouraged to reflect this in their teaching.

Additionally, corrective measures need to be implemented to help students fully grasp the concepts underlining the changes in pH during titrations including the effects produced by a consideration of the strengths of both acid and base.

Module 3: Chemistry of the Elements

Question 3

Syllabus Objectives: 5.1, 5.2. 5.7, 5.10
Mean: 4.72; Standard Deviation: 2.58

This question focused on transition elements – their definition, electronic configuration and implications, compounds, ligand replacement reactions and shapes of complexes.

Candidates demonstrated great difficulty in answering this question. Most candidates were able to obtain marks for Parts (b) and (c) (i).

Candidates found it very challenging to give an adequate definition of *transition element*. The fact that the definition must include the notion of the formation of one or more ions with an incomplete d sub-shell was not appreciated leading to definitions which included the elements scandium and zinc!

Again, candidates' lack of practical experience was evident as the majority was unable to correctly identify the colour changes — pink, brown and blue — involved in the reaction of aqueous cobalt(II) compounds in environments of ammonia and chloride ions respectively.

The chemistry of the transition elements forms a relevant part of study in the present world system and teachers need to present this topic so as to highlight the many applications of these elements and their compounds in critical areas of life in the 21st century. An experimentally based approach offers a sound way of encouraging curiosity and interest in the various areas of

- defining concepts and terms
- applying chemical terms, electronic configuration to some chemical properties, for example, stability of varying oxidation states – Mn^{2+}/Mn^{3+} and Fe^{2+}/Fe^{3+}
- writing structures of complex ions and paying attention to bonds formed with coordination atoms of ligands involved
- deducing possible shapes of complexes with respect to the number of coordinating ligands.

Section B

Module 1: Fundamentals in Chemistry

Question 4

Syllabus Objectives: 2.9, 2.10, 5.1-5.4
Mean: 6.20; Standard Deviation: 3.37

This question tested candidates' appreciation of the

- concept of hybridization in the tetravalent carbon atom,
- use of the VSEPR theory in explaining the bonding arrangements in molecules,
- ideal gases as described by kinetic theory with mathematical applications using the ideal gas equation.

Candidates' performance was satisfactory in Parts (a), (b) (i) and (b) (ii). Candidates were able to obtain marks in the areas which required simple recall — electronic configuration of the carbon atom, assumptions of kinetic theory for ideal gases and the conditions under which gaseous behavior becomes non-ideal.

However, candidates showed great difficulty in clearly explaining the process by which the carbon atom showed tetravelency in the ethane molecule, as well as deducing the types of orbitals used and the arrangement of bonds formed as provided by the VSEPR theory.

Expected Response:

Each carbon atom has four bonded pairs. The extent of the repulsion between the bonding pairs result in a tetrahedral arrangement around each carbon atom with four equal bond angles of 109.5°.

Candidates also lost marks in the calculation by failing to convert the given information into appropriate units.

Module 2: Kinetics and Equilibria

Question 5

Syllabus Objectives: 1.8, 5.1, 5.5
Mean: 4.89; Standard Deviation: 3.54

This question sought to assess candidates' understanding of the concepts of solubility, solubility product with mathematical applications and the use of the distribution of energies of a gas to explain the relationship between temperature and reaction rates.

Again, candidate performance was weak. Several candidates lost marks for incomplete or partial definitions. On the other hand, candidates earned marks for the expression of the solubility product and sketches involving the distribution of energies of particles in a gas.

Candidates' performance indicated superficial acquaintance with the subject matter in Part (b), However, a full comprehension of the concepts involved and the deductive reasoning skills required to correctly solve mathematical problems were not evident.

Expected Responses:

(b) (i) Solubility of lead (II) azide:

Molar mass $Pb(N_3)_2$
$= 207 + 2 \text{ x } (14 \text{ x } 3)$
$= 291$

$0.025 \text{ g} / 291 \text{ g mol}^{-1} = 8.59 \text{ x } 10^{-5}$

In 1000 cm^3:
$8.59 \text{ x } 10^{-5} \text{ x } 10 = 8.59 \text{ x } 10^{-4}$

(ii) Solubility product of lead (II) azide:
$K_{sp} = [Pb^{2+}] [N_3^-]^2$

(b) (iii) K_{sp} of $Pb(N_3)_2$

Let sol be s

$[Pb^{2+}]$ = s

$[N_3^-]$ = 2s

$s \times 4s^2$ = $4s^3$

$4 \times (8.59 \times 10^{-4})^3 = 2.54 \times 10^{-9}$ $mol^3\ dm^{-9}$

Module 3: Chemistry of the Elements

Question 6

Syllabus Objectives: 1.1, 1.4, 4.2
Mean: 2.95; Standard Deviation: 2.84

The focus of this question was the concept of polarization and its implication for the difference in pH of the aqueous solutions of the chlorides of sodium and aluminium, and the response required for the successful identification of the halide ion in the data analysis.

Part (b) was poorly answered. Candidates were unsure of the term *polarization* and as a result faced severe challenges in explaining the differences in pH between aqueous solutions of NaCl and $AlCl_3$.

Expected Responses:

(b) (i) Ionic size decreases from Na → Al.

(ii) An aqueous solution of sodium chloride contains hydrated ions producing a neutral solution (pH 7).

$NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$ **(1)**

The high charge/radius ratio of aluminium ion removes protons from water molecules producing an acid solution (pH 3).

$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightarrow [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

OR

$AlCl_3 + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3HC1(aq)$

Generally, candidates were unable to deduce the identity of the halide ion in Part (c). Candidates failed to appreciate the difference between the terms halogen and halide ion, referring repeatedly to iodide and bromide ions as iodine and bromine. Candidates, even at this level of study, continue to find difficulty writing balanced equations (both ionic and formula).

Expected Responses:

(c) (i) Iodide

(ii) $2\ RbI(aq) + Cl_2(aq) \rightarrow 2\ RbCl(aq) + I_2(aq)$

(iii) Add $Pb(NO_3)_2(aq)$ to solution of halide ion – a yellow precipitate will form.

Teachers need to

- devise strategies to explain clearly the concept of polarization as the distortion of an electric cloud by an adjacent ion or dipole — this in the context of electronegativity and polarity.
- foster the critical thinking skills of students so as to foster competence in problem solving.

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

Syllabus Objectives:
Mean: 20.46; Standard Deviation: 5.85

Question 1

This question required candidates to perform a volumetric analysis exercise involving a redox reaction. Candidates were asked to titrate stated volumes of a standard solution of thiosulfate ions with standard aqueous solution of iodate ions. They were then asked to determine the ratio of iodate to iodide ions and thus write the balanced equation between thiosulfate ions and iodine.

Expected Responses:

(c) Starch combines with the iodine in solution to form a blue – black complex which becomes colourless at the end point of titration.

(d) $I_2 + 2e^- \rightleftharpoons 2I^-$

(e) $2S_2O_3^{2-}\,(aq) + I_2(aq) \rightleftharpoons S_4O_6^{2-}\,(aq) + 2I^-\,(aq)$

Candidate performance was inconsistent. In the case of the actual titration, most candidates were able to obtain at least three out of the possible six marks; marks were lost for accuracy and failure to obtain consistent results. Candidates are reminded that volume observations must be recorded to two decimal places. Most candidates found the calculations a challenge and as a result not many marks were obtained. This is a weak area in candidates' knowledge and needs better preparation.

Expected Response:

(f) (i) 1000 cm^3 of thiosulfate contain 0.10 mole, V cm^3 of thiosulfate contain

$$\frac{0.10 \text{ mole x V cm}^3}{1000 \text{ cm}^3}$$

(ii) Based on the equation in (e) the number of moles of iodine produced is

$$\frac{\frac{1}{2} \text{ x } 0.10 \text{ moles x V cm}^3}{1000 \text{ cm}^3}$$

(f) (iii) Mole iodate ion present in 20.0 cm^3:

KIO_3 = 39 + 127 + 48 = 214 g
3.00 g = 3.00 g/214 g/mol^{-1}
= 0.014 mole
1000 cm^3 of iodate solution contain 0.014 mole

20.0 cm^3 of iodate solution contain

$$\frac{0.014 \text{ moles x } 20 \text{ cm}^3}{1000 \text{ cm}^3}$$

= 0.00028 mole

Number of moles iodine formed from one mole iodate:

0.00028 moles KIO_3 produce

$$\frac{\frac{1}{2} \text{ x } 0.10 \text{ x } V}{1000} \text{ mole } I_2$$

∴ 1 mole KIO_3 produce

$$\frac{\frac{1}{2} \text{ x } 0.1 \text{ x } V}{1000 \text{ x } 0.00028}\ I_2$$

Question 2

This data analysis question tested the candidates' ability to

- read accurately volumes from a graduated gas syringe
- design a table to present the information obtained
- plot a graph of volume against time
- respond to queries about the rate of the reaction.

This question was answered satisfactorily. Candidates showed a reasonable level of competence in responding to the first three of the above objectives, which carried a total of nine marks. However, the response to the final objective, which included the calculation of rates and the effects of the various conditions on reaction rates, presented serious challenges.

Question 3

This question assessed candidates' level of competence in the skills associated with the planning and design (PD) of practical investigations. Candidates were asked to design an experiment to investigate the difference between the hardness of water in urban as distinct to rural environments.

Candidates' overall performance was very weak. While they were generally able to formulate appropriate hypotheses, producing corresponding aims presented some challenge. Candidates appeared to lack the relevant background knowledge to provide credible methods as the basis for providing answers to the questions of reagents and apparatus and procedures which involved the relevant variables.

This is an area which requires greater attention in developing the skills needed for candidates to acquire the competence to answer such questions satisfactorily.

UNIT 2

Paper 01 – Multiple Choice

Performance on this paper was very good — candidates responded to the majority of questions correctly. Candidates seemed to experience the greatest challenge with questions focusing on some aspects of spectroscopy (Module 2) and on free radical reactions on the upper atmosphere (Module 3).

Paper 02 - Structured/Essay Questions

Section A

Module1: The Chemistry of Carbon Compounds

<u>Question 1</u>

Syllabus Objectives: 2.2, 2.4, 2.7, 2.13, 2.17, 3.2
Mean: 4.92; Standard Deviation: 2.84

This question assessed candidate competence in the areas of

- substitution in alkanes via chain reaction and the associated steps of initiation, propagation and termination,
- the source of the basic character of amines, their measurement in terms of K_b and pK_b
- the differences in basic strengths between aliphatic and aromatic amines (ethylamine/phenylamine) and amides (ethanamide).

Candidate performance was very inadequate. Candidates generally earned marks for

- stating the role of UV radiation in the above reaction in Part (a) (i)
- writing the expression for the dissociation constant of the amine RNH_2
- identifying ethylamine as a stronger base than phenylamine by virtue of their pK_b values.

Many candidates found it challenging to write equations which explain the propagation stage of the stated reaction, the difference in pK_b values of the above amines and the reduction in basic character of ethanamide.

Several candidates did not

- understand the relationship between basic strength and pK_b value with many failing to recognize that ‘the greater the pK_b value, the lower the basic strength’.
- appreciate that the strength of aliphatic amines is enhanced by electron-donating groups in increasing electron availability at the nitrogen atom while the delocalization of the lone pair on nitrogen in the aromatic amines results in the opposite response.

Again, many candidates were ignorant of the reactions of the functional groups presented in Part (d). This recurring lapse underlines the absence of appropriate practical learning experiences.

Module 2: Analytical Methods and Separation Techniques

Question 2

Syllabus Objectives: 3.2, 3.3, 3.4, 3.5, 4.1, 4.2
Mean: 7.73; S.D.: 3.21

This question centered around the electromagnetic spectrum, and the relationship of frequency and wavelength. It also focused on the use of the gravimetric method in chemical analysis.

Candidates' responses to the various sections of the question were satisfactory. Many candidates showed familiarity with the different parts of the electromagnetic spectrum and were able to do the calculation requested.

In the case of the use of the gravimetric method, candidates were generally able to state the purpose behind the various stages of the procedure and the apparatus required.

Some candidates seemed to be confused about the relationship between wavelength, frequency and energy that was required in Part (b). In Part (c), the majority of candidates could not identify a use of gravimetric analysis in quality control.

Expected Responses:

(b) Using $C = \nu\lambda$

$\Rightarrow 3.0 \times 10^8 = 4.5 \times 10^{15}\lambda$

$\Rightarrow \frac{30 \times 10^8}{4.5 \times 10^{15}} = \lambda = 6.7 \times 10^{-8}$ m.

(c) Use of gravimetric analysis in quality control:
Air quality (detecting pollutants in air)
Assaying of minerals (determining composition of minerals) any other relevant use.

Many candidates were able to determine correctly the formula of $Na_2SO_4 . xH_2O$ using a number of differing approaches. The manipulation of the information using moles was good.

Module 3: Industry and the Environment

Question 3

Syllabus Objectives: 1.1, 1.2, 4.1, 4.2, 4.3
Mean: 7.20; Standard Deviation: 3.81

This question tested candidates' knowledge of the Haber process and the application of Le Chatelier's principle in explaining the various conditions affecting the yield of the compound and the identification of the different steps in the production process.

Given the fact that this topic is a continuing one from CSEC, the overall performance was just satisfactory. Candidates were generally able to obtain marks for writing the relevant equation, stating the working conditions and suggesting factors influencing the siting of the plant.

However, marks were lost in the use of Le Chatelier's principle to explain the effect on yield with many responses presenting convoluting and contradictory statements. Candidates also failed to gain marks in the identification of the steps in the flow diagram of the manufacturing process.

Expected Responses:

(b) (i) The process is an exothermic process in the forward reaction to produce ammonia. An increase in temperature will result in the equilibrium position shifting to the left and a decrease in the yield of ammonia.

(ii) The forward reaction favours an increase in pressure due to lowering of the total number of molecules. There should be a higher yield of ammonia.

(c) (i) The processes are:
A – Steam reforming
B – Dissolving of CO_2 in water/caustic soda
D – Condensation

(ii) A catalyst (finely divided iron) is required.

(iii) Liquid (ammonia)

Teachers need to carefully review the teaching of the concept of chemical equilibrium which would allow students to clearly describe the effects of the various conditions affecting such equilibria which is at the core of the Le Chatelier's principle.

Section B

Module 1: The Chemistry of Carbon Compounds

Question 4

Syllabus Objectives: 1.6, 1.8, 2.7, 2.8
Mean: 4.77; Standard Deviation: 3.39

This question focused on the chemistry of halogenoalkanes — the three types, isomerism, and substitution reaction among others.

Generally, candidates were able to distinguish between primary, secondary and tertiary halogenoalkanes as well as to describe the result of the silver nitrate test. However, the other parts were very poorly done.

In Part (b), the majority of candidates misinterpreted the question as stated and hence deduced the isomerism as positional.

The question stated that 'Compound A was *one* of two…… bromoalkanes', hence this *one* compound existed in two isomeric forms. This would indicate that there were two compounds with the *same* molecular mass; the isomerism then would be optical and the Compound A would be 2-bromobutane.

Candidates were given credit for the positional isomerism response and provided that further responses were consistent, marks could be obtained. However, at this level, candidates should have been able to carefully read and interpret the statement as written.

In Part (c), the majority of candidates was unable to explain the mechanism involving the reaction with aqueous sodium hydroxide. The use of arrows to indicate the movement of electrons proved to be very challenging for candidates.

The above deficiencies need to be addressed by teachers and students preparing for this part of the course.

In Part (d), candidates were expected to indicate that a creamy yellow precipitate would be formed between a solution of D and aqueous silver nitrate represented by the following equation.

$$NaBr\ (aq) + AgNo_3\ (aq) \rightarrow NaNO_3\ (aq) + AgBr\ (s)$$

OR $$Br\ (aq) + Ag^{+}\ (aq) \rightarrow AgBr\ (s)$$

Module 2: Analytical Methods and Separation Techniques

<u>Question 5</u>

Syllabus Objectives: 7.1, 7.2, 7.3
Mean: 5.51; 3.64

This question centered on mass spectrometry as an analytical tool and candidates were required to explain the various components of the mass spectrometer and the identification of the various fragments provided by the mass spectrum of a compound leading to the writing of its structural formula.

Generally, candidate performance was weak. There were inconsistent responses to the various sections of the question. Candidates were able to obtain at least two marks for describing the workings of the various parts of the spectrometer. Marks were also gained for recognizing that the (M+1) peak was related to the number of carbon atoms present in the compound and identifying some of the fragments involved.

In Part (c), candidates showed very weak deductive skills in answering the various parts of the question; they should be encouraged to identify the different fragments by writing their correct formulae.

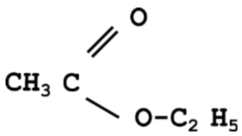
Expected Responses:

(c) (i) 88

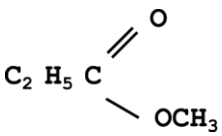
(ii) 43

(iii) $(CH_3.)+$
$(C_2H_5.)+$
$(CH_3CO.)+$

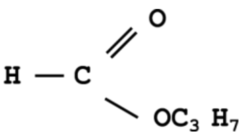
(iv)



(d)



or



Module 3: Industry and the Environment

Question 6

Syllabus Objectives: 5.1, 5.4, 9.1-9.8
Mean: 6.82; S.D.: 3.34

This question tested candidates' understanding of the processes involved in the maintenance of the level of stratospheric ozone, the resulting effect on human life by its depletion, the fermentation process and its economic value to Caribbean countries.

Responses to Part (a) were quite modest. Candidates showed a superficial grasp of the processes of destruction of stratospheric ozone and hence were severely handicapped in the writing of the relevant equations. Part (a) (i) carried five marks and on average, candidates were only able to obtain about two of these marks. For Part (a) (iii), candidates were generally able to cite two effects of ozone depletion on human life.

For Part (b), it was surprising how many candidates found difficulty explaining the fermentation process and writing the equation for the production of alcohol.

Part (c) focused on the importance of the fermentation industry to Caribbean economies. Most candidates were able to obtain the three marks for commenting on this.

It should be noted that for CXC purposes, the term *comment* requires students to state an opinion or view and support it with appropriate reasons.

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

Syllabus Objectives: Mod 1-2.4; Mod 2-2.3, 2.4, 2.5
Mean: 21.00; S.D.: 7.39

Question 1

In this question candidates were asked to carry out a thermometric titration leading to the standardization of an aqueous solution of ethanoic acid.

Candidates' performance was satisfactory with candidates receiving most of their marks for the recording of observations of temperature and the plotting of the associated graph.

These two components carried a maximum of 11 marks out of a total of 18. The remaining components which involved knowledge of the theoretical basis of the investigation proved problematic and very few marks were obtained.

Question 2

This data analysis question concerned the accurate reading of burette readings in a volumetric analysis involving the titration of manganite(VII) and iron(II) ions leading to the determining of the percentage purity of an iron(II) compound.

General performance was weak. As in the corresponding question in Unit 1, most marks were gained in the reading of the specific instrument and the presentation of the acquired information. Most candidates were unable to carry out the required calculations, suggest the colour change at the end-point and describe the steps in making the standard solution of the iron(II) salt.

It is clear that candidates are not given adequate practical experiences and as such lack both the theoretical and practical competence to adequately deal with questions such as this one.

Expected Responses:

(a) (iii) $\frac{10.5 + 10.6}{2} = 10.55 \text{ cm}^3$

(iv) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$

(v) Concentration of $MnO_4^-(aq)$ = 0.02 mol dm^{-3}
Number of moles of MnO_4^- = (10.55 x 0.02 x 10^{-3})
Number of moles of $Fe^{2+}(aq)$ = (5 x 10.55 x 0.02 x 10^{-3})

Number of moles of $Fe^{2+}(aq)$ in 1 dm^3

$$= \frac{5 \text{ x } 10.55 \text{ x } 0.02 \text{ x } 10^{-3}}{20}$$

$$= 5.275 \text{ x } 10^{-2} \text{ mol dm}^{-3}$$

Concentration of Fe^{2+} = (5.275 x 10^{-2} x 56)

= 2.95 g dm^{-3}

(vi) % Purity = $\left(\frac{2.95}{10} \text{ x } 100\right) = 29.5\%$

(b) Steps to prepare iron (II) sulfate solution:

- Dissolve the 10 g of $FeSO_4$ in minimum volume of H_2SO_4 in a beaker.
- Transfer quantitatively to a 1 dm^3 volumetric flask.
- Make up to mark with distilled water.
- Stopper and shake/invert to ensure thorough mixing.

Question 3

This question tested candidates' level of competence in the planning and designing of a practical investigation.

This question was poorly done by the majority of candidates. Most of them received marks for stating a hypothesis but thereafter, responses were very inconsistent resulting in an overall small number of marks.

Paper 031 – School-Based Assessment (SBA)

General Remarks

The overall level of compliance with the guidelines for the submission of samples for moderation continues to improve. However, as a reminder to teachers the following are to be noted:

- Samples submitted should correspond to those computer generated by the Council.
- Activities should be aligned to the syllabus objectives.
- 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 analysis.
- 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.
- Titles stating what is happening either in tables or graphs must be clearly written.
- Expected results and the marks awarded must be clearly stated in the mark scheme and indicated in the laboratory books as well.

<u>Observation/Recording/Reporting, (O/R/R)</u>

There continues to be improvement in the assessment of this particular skill and teachers are to be commended. The following points, however, needs repetition:

- In the reporting of qualitative analysis, the terms *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.* In the case of *acidic* and *basic, the observations* resulting from the appropriate tests should be recorded.
- Discussions and conclusions, calculations and information obtained from graphs are all assessed as Analysis and Interpretation (A/I) and not as ORR.

<u>Analysis and Interpretation (A/I)</u>

The criteria testing this skill need to be more challenging — calculations based on volumetric analysis should go beyond simple 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.

All calculations including units are to be checked carefully for each candidate.

Inferences must match the observations for the marks to be awarded.

<u>Planning and Design (P/D)</u>

Teachers continue to show improvement in the assessment of this skill, however, great difficulty is still being shown in the formulation of 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 and should consist of scenarios from which hypotheses and variables may be generated.

Many mark schemes tend to be extremely rigid and students are expected to use only one particular method; this tends to limit creativity.

Too much information is given to the students in the problem statements leading them to a particular solution.

Hypothesis should be clearly stated and substance(s) being measured must be quantified, that is, mass/concentration and so on, must be identified in the hypothesis as criteria being analyzed.

Expected results should explain how the data gathered can be used to refute or prove the hypothesis. Assumptions, Limitations and Sources of Error should not be assessed as one criterion; students should be taught to appreciate the differences and be assessed accordingly.

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. For example, an assignment whose underlying theoretical basis centres on the identification of the alkene group is unacceptable for use as a Unit 1 exercise.

An example of an inappropriate PD problem statement is: “Jelees and Rhenez are in disagreement over the order of reaction of iodine in a reaction between iodine and propanone. Jelees thinks that the order of reaction with respect to iodine is first order, whereas Rhenez believes that the order of reaction with respect to iodine is second order. Plan and design an experiment to help them to settle this disagreement”. This problem statement is unacceptable since the scenario is not new/novel and requires no creativity on the part of the student as the answer can be lifted from a textbook.

Integrity of Samples

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

- students are to engage in individual work, especially for discussion, calculation and 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 summative assessment.*