CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2003

CHEMISTRY

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GENERAL COMMENTS

Overall, candidate performance on Unit II theory papers was fairly satisfactory with the mean score on Papers 01 and 02 approximately 40 per cent of the maximum possible score. There was, however, a noticeable decline in the standard of performance on Unit I compared with the performance in 2002. Mean scores for Papers 01 and 02 averaged at about 30 per cent of the maximum possible score. Teachers are reminded that candidates should be prepared for external examinations at the end of EACH year, unlike the previous examinations in which a two year programme was followed.

UNIT 1

Attention should be paid to:

(i) Fundamentals in Chemistry, for example, (a) Introduction to Chemical Equilibrium and (b) Organic Chemistry in a manner that emphasizes the underlying principles and aims for conceptual understanding instead of rote memorization.

(ii) Equations (molecular and ionic).

UNIT 2

Attention should be paid to:

(i) Equilibrium concepts and their applications as required for calculations of Kp, mole fractions, partial pressure (for gases).

(ii) Patterns and trends in the chemistry of the elements and explanation of behavior of the elements in terms of structure and boading.

(iii) Equation (molecular and ionic).

INTERNAL ASSESSMENT

The internal assessment continues to provide a satisfactory level of performance. The main areas of concern are the Planning and Design component, and Analysis and Intepretation.

A. Projects (Analysis and Interpretation)

Teachers are reminded that candidates must produce their own analysis and interpretation of data, which should not be a descriptive summary of the literature or an analysis that is taken from a text book. Teachers must be satisfied that the projects

chosen by students fulfill the criteria for the assessment of the required skills. The following example shows a project that was developed from a syllabus objective.

Example: Unit I Module 1

Specific Objectives 2.4: discuss the use of radioisotopes.

Project Aim: To examine some of the many uses of radioisotopes and to show their importance in our lives.

Below is the structure of one of the sections of the project that is meant to fulfill criteria for A/I.

Anaylsis and Interpretation	Nuclear Medicine • Appreciation of limitations • Historical, social and economic perspectives • Anticipated outcomes.

B. Practical Activities (Planning and Design)

Teachers are reminded that:

(i) All planning and design assignments need not be executed. When executed – the plan/design must be included in the laboratory book with the mark scheme that identifies the skills tested for P/D.

Example: Hypothesis, data collection and analysis strategies, identification of variables. The executed assignment can be assessed for one or two of the following: M/M, ORR or A/I.

(ii) The mark scheme for M/M must not include A/I skills. For example, if an acid/base titration is used to assess M/M, the burette reading can be used as an indication of measurement/manipulation skills, but calculations of molar concentration and mass concentration can be used for A/I, not measurement/manipulation skills.

(iii) At least two relevant practical activities must be done to fulfill the Internal Assessment requirements for each module.

(iv) Laboratory books (practical work) and projects from each of the five selected candidates must be submitted. It means, therefore, that the selection of the five candidates must be based on their overall performance on internal assessment (practical work and projects) and the work of these five candidates submitted to CXC.

DETAILED COMMENTS

UNIT 1

PAPER 01

Question 1

Specific Objectives: 2.2, 2.3

Mean: 5.03
S.D.: 2.52
Range: 0-10

Candidates were expected to demonstrate their understanding of naturally occurring radioactive decay and to apply these concepts to a selected example.

Most candidates balanced the equation in part (a) that illustrated α - decay of $^{238}_{92}U$. However, many made the common error that the atomic number decreases on emission of a β - particle as

$$^{234}_{90}X \rightarrow ^{234}_{89}Y + ^{0}_{1}\beta$$

In part (b), the most common error was that candidates did not indicate a difference in the degree of deflection of α and β particles. Additionally in part (c), many candidates did not refer to the u/p ratio that was greater than needed for stability and that β - decay would result in a decrease in the u/p ratio which would produce an atom in (closer to) the band of stability.

Question 2

Specific Objectives: 4.4, 4.6, 4.7

Mean: 2.09
S.D.: 1.85
Range: 0-9

This question assessed candidates' understanding of intermolecular forces and molecular shape.

Most of the candidates were unable to attain a score of at least 3/6 awarded for identification of description of intermolecular forces. Candidates were unable to differentiate between intermolecular and intramolecular forces. For those candidates who identified the intermolecular forces between ammonia as Hydrogen bonding and Van der Waals forces as occurring between CO_2 molecules, the explanations were often imprecise so that examiners did not get a sense that the H-bonds were formed between neighboring molecules or in the case of CO_2 that the induced dipols were formed as a result of the random motion of electrons within the molecule.

Many candidates were unable to suggest the correct formula $BeCl_2 \bullet 2NH_3$ for part (b) and insufficient care was noted in their dot/cross diagrams of the electron distribution. Many candidates did not draw complete electron shells for all atoms.

About half the candidates seemed to have understood that the shape of a molecule is derived by consideration of the electron distribution among the central atom.

Question 3

Specific Objectives: 9.3, 9.4, 10.1

Mean: 2.42
S.D.: 1.95
Range: 0-10

This question was based on candidates' knowledge and understanding of energetics. Specifically candidates were tested on bond energies, enthalpy change of combustion and the application to the behavior of an unknown DMSO.

Many candidates were unable to explain the terms. They did not appreciate that there were key ideas each of which must be expressed fully. For example, enthalpy change of combustion must consider the following:

- energy given out
- one mole of compound
- completely burnt in oxygen
- standard conditions

Many candidates gave definitions such as 'the heat given out when something burns in oxygen'. Even worse, some spoke about the heat required.

It was surprising that many candidates could not determine the products of combustion of DMSO and balance a chemical equation.

Additionally, many candidates seemed unaware that enthalpies of reactions are a result of the difference between energy required to break bonds, which is an endothemic process, and the energy released when bonds are formed, which is exothemic.

Many candidates seemed to be unaware of the properties of a good fuel, as evidenced by answers such as it is an organic liquid or it is volatile, instead of reference to ΔH^{θ}.

Question 4

Specific Objectives: 1.5, 1.7, 3.2

Mean: 3.00
S.D: 2.73
Range: 0-10

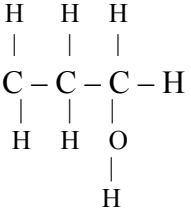
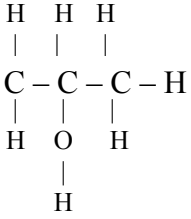
This question was based on candidates' knowledge of reactions of functional groups and reactions of organic alcohols.

Many candidates were familiar with reaction of $\text{C}=\text{C}$ and $-\text{C}(=\text{O})-\text{O}-\text{H}$.

However the idoform reaction that is characteristic of $CH_3-\underset{\displaystyle OH}{\overset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-$ and the identification of  were less common responses.

In part (b), candidates were expected to present the displayed formulae for compounds B, E, F and G.

Many candidates wrote the condensed formulae, however, and identified E, F and G correctly. A few candidates did not use the RMM given to identify the compounds E and F. A common error was that candidates identified

B as  instead of 

Question 5

Specific Objectives: 2.2, 2.3

Mean: 2.66
S.D.: 2.51
Range: 0-10

This item was based on the reactions of alkanes and halogenoalkanes and the mechanisms involved in the conversion of alkanes to halogenoalkanes and of halogenoalkanes to alkanes and alcohols [free radical substitution, elimination and nucleophilic substitution].

Generally, this question was poorly done.

(a) Mechanisms of reactions were not well understood. Candidates described the mechanism as condensation instead of elimination, and many spoke generally of substitution instead of nucleophilic substitution.

(b) (i) Some candidates stated light as the condition for reaction instead of UV light/radiation or sunlight. The condition 'excessive light energy' was also used and should not be encouraged.

(ii) Many candidates correctly stated the conditions as concentrated alkali or alcoholic alkali, but failed to state that heat was required.

(c) (i) Many candidates were not familiar with the steps involved in free radical substitution, omitted the symbol '•' for free radical or used ionic charge symbols or showed 'H•' being formed during propagation.

(ii) Many candidates did not attempt this part of the question, or failed to show the formation of the carbocations.

Question 6

Specific Objectives: 1.5, 3.4, 3.5

Mean : 2.54
S.D.: 2.14
Range: 0-9

Candidates were required to write structural formulae, to explain reactions of methylbenzene, to distinguish among alcohols, phenols and organic tests and to explain the differences in acidity of these organic compounds.

This question was not handled well by the vast majority or candidates. Among the common errors were candidates:

(a) (i) indicated substitution of the methyl groups instead of electrophilic substitution of hydrogen in the aromatic ring.

(ii) were unable to employ the convention that is used to represent the movement of electrons. Arrows should represent the movement of electrons from areas that are electron rich to electron deficient.

(iii) were unable to express ideas and concepts cogently.

Question 7

Specific Objectives: 1.1 – 1.3

Mean: 2.77
S.D.: 1.70
Range: 0-8

This item was based on the topic "uncertainty in measurement" and tested candidates' understanding of the following concepts – calibration, precision, accuracy and the application of these to the use of the pipette.

Modal score range 3-4 by $\frac{87}{177}$ or 49 per cent of candidates.

Fourteen per cent achieved $\geq$ 5 (at least half the marks). Six per cent in range 7 – 8.

(a) Most candidates did not refer to the use of standards in the process of calibration.

(b) Candidates confused the concepts 'accuracy' and 'precision', for example, candidates said accuracy refers more to the consistency of a set of readings instead of accuracy is the extent to which a measurement approaches the true value of the quantity. Some stated that precision gives the expected results instead of "the degree to which there is agreement between a number of measurements of the same quantity".

NB: Measurements may be precise but inaccurate.

(c) The formula for Standard Deviation, (S.D.) was often incorrect – the square root sign was applied only to the numerator.

(d) Poorly done. There was little appreciation for the inclusion of the S.D. in the response.

(e) Candidates seemed to have misinterpreted this part. Many who attempted a response wrote either density or moles instead of temperature. (See Appendix 1 for solution).

Question 8

Specific Objectives: 2.15 – 2.16, 3.4

Mean: 1.53
S.D.: 1.54
Range: 0-9

This question addressed the aspect of the syllabus that dealt with UV/VIS spectroscopy, including candidates' knowledge of and ability to use, Beer-Lambert's law.

The modal range for this item was 0-2 achieved by 75 per cent of the candidates. A mere nine per cent achieved a score ≥ 5.

Candidates were not very familiar with this topic and were also unable to calculate the RMM of P and to determine the mass of solute in a given volume of solution from knowledge of mass concentration.

Some of the common errors were:

(i) the position of UV/value or range was given instead of features of UV radiation
(ii) candidates omitted units
(iii)candidates were unable to use Beer-Lambert's law to determine molar concentration.

See Appendix 2 for solution.

Question 9

Specific Objectives: 2.28 – 2.31

Mean: 3.04
S.D.: 2.27
Range: 1-9

Candidates were required to demonstrate their understanding of the general principle upon which chromatographic separation is based and to interpret a chromatogram.

Surprisingly the modal range for this item was also 0-2 achieved by $\frac{73}{184}$, about 40 per cent of the candidates. Approximately 30 per cent achieved a score $\geq$ 5 out of 10.

The common errors were:

(a) The principle was not stated clearly

(b) (i) Candidates did not mention that the mobile phase carries the components of the analyte.

(ii) The term "absorb" was frequently used instead of "adsorb".

(c) Candidates did not give a reason for the difference in retention times although many stated correctly that Y was eluted before Z, that is, lower retention time for Y than Z.

UNIT 1

PAPER 02

Question 1

Specific Objectives: 6.1, 6.2, 6.3

Mean: 3.57
S.D.: 2.04
Range: 0-10

Candidates were expected to apply their knowledge of definitions of redox to specific examples cited, to write balanced ionic half-equations and to demonstrate their familiarity with simple laboratory redox reactions.

Candidates performed satisfactorily on part (a) of the question. Some answers were too general. For example, candidates spoke about electron transfer in general terms. They did not state explicitly the number of electrons transferred, for example, that each Fe^{3+} ion accepts one electron from the I^- ion or that the oxidation number of I^- increased from –1 to 0. Some candidates also mentioned that H^I ions had gained electrons and were reduced. Most

candidates constructed appropriate half equations, though in some cases the equations were not balanced, for example,

$$I^- \rightarrow I_2 + e$$

Part (b) of this question was not handled as well. Candidates must be reminded that they must describe initial and final colours and/or states observed. Most did not provide the initial colour of solutions. It also appears that some candidates do not appreciate the meaning of the word "decolorized". For example, it was recorded that the solution was decolorized from purple to brown.

Question 2

Specific Objectives: 3.2, 3.3

Mean: 1.78
S.D.: 1.92
Range: 0-9

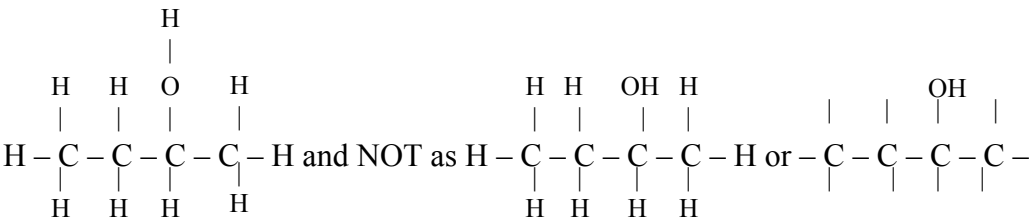
Question was poorly done.

In general, candidates were not well prepared to describe chemical reactions of functional groups. Approximately 68 per cent attained scores within the range of 0-2 and 12 per cent attained at least half of the total marks. Seven per cent of the candidates did not respond.

(a) Many candidates omitted full details, for example, warming. Candidates used acidified reagents then tested with litmus.

Candidates were unfamiliar with reagents used to test, and the results/observations of the tests.

(b) More attention should be paid to reactions of functional groups – reagents and conditions. Candidates must also be reminded that all bonds and atoms must be shown in the displayed formula of an organic compound for example, X should be written as



Question 3

Specific Objectives: 2.18, 2.19, 3.5

Mean: 3.79
S.D.: 2.28
Range: 0-10

Candidates were fairly well prepared to respond to this item that was based on knowledge of IR spectroscopy.

The modal range was 5-6 achieved by approximately 32 per cent of the candidates. About 14 per cent attained scores of 7 and 8.

Parts (c) and (e) presented most difficulty. Candidates were required to perform calculations, which continues to be a challenge for them, and to give details in the preparation of a sample for IR analysis. In general, more attention should be paid to objective 2.19. (See Appendix 3 for solution)

Questions 4

Question 4 was more popular than Question 5, selected by approximately 90 per cent of the candidates.

Specific Objectives: 8.1-8.4

Mean: 9.70
S.D.: 4.48
Range: 0-19

This question tested candidates' knowledge and understanding of the kinetic theory and their ability to use the gas laws.

Many candidates were unable to express themselves lucidly in their explanation of observation I and II, however, a large number of candidates used Boyle's law appropriately in obtaining a volume of 253.1cm^3 in answer to (b) (i).

Surprisingly, in response to (b) (ii) many candidates drew a graph of V vs P instead of Vvs T(°C). In general part (c) was quite well done, with candidates correctly stating the differences between a gas and a liquid in terms of (i) kinetic energy and (ii) strength of the intermolecular forces.

Common errors were that many candidates

(a) could not explain how a gas exerts pressure on the walls of the containers. Many believed that the collisions between the gas molecules themselves cause pressure, rather than collisions between the molecules and the walls of the container.

(b) confused temperature modes (K and °C). Many said that an ideal gas occupied zero volume at 0°C or –273K.

Question 5

Specific Objectives: 7.1-7.3

Mean: 5.91
S.D.: 3.35
Range: 0-14

Very few candidates (approximately 10 per cent) selected this item that was based on principles of chemical equilibrium. Based on their responses, it was evident that they had not been exposed to simple practical examples of equilibrium reactions.

The features of chemical equilibrium can be illustrated practically, for example, the effect of acid/alkali on indicators or from pictures in texts that illustrate reversibility. For example, the effect of pressure in the $2NO_2 \rightleftharpoons N_2O_4$ system. Candidates were expected to apply their understanding of equilibrium concepts to the unfamiliar example cited (use of Knowledge), hence a formal definition of Le Chatlier's Principle was not required.

Question 6

Specific Objectives: 1.5-1.9

Mean: 6.43
S.D.: 3.89
Range: 0-19

Candidates were tested on their understanding of various types of isonerism – chain, positional, functional group and stereoisonerism. Based on their responses, attention must be paid to the following:

- correct use of IUPAC terminology with dashes, commas inserted correctly
- use of the longest continuous carbon chain as the basis for names
- that each atom and all bonds must be shown when writing displayed formulae
- that candidates differentiate between displayed formula and condensed formula.

Question 7

Specific Objectives: 3.1, 3.2, 3.6, 3.7

Mean; 2.43
S.D.: 2.45
Range: 0-11

This item determined candidates' knowledge of functional groups and the reaction of aromatic acids, esters and amides.

The modal range for this item was 0-5.

Many candidates were unable to identify the phenolic – OH or the amide linkage. The best known functional group was the – COOH group.

Parts (a) (iv) and (b) presented most difficulty. Candidates were seemingly not very familiar with the reagent ethanoyl chloride or ethanoic anhydride. Many suggested ethanoic acid as an appropriate reagent for conversion of 2-hydroxybenzoic acid to aspirin. They were also not very comfortable with the section of the syllabus that addresses properties and behaviour of organic nitrogen compounds. Many were unable to deduce the formula of A as 2-amino propanoic acid based on the properties exhibited and to cite conditions for the reactions of phenylamine.

Question 8

Question 8 was not as popular as Question 9.

Specific Objectives: 2.12 – 2.14, 3.3

Mean: 5.67
S.D.: 3.75
Range; 0-14

This question was based on the topic Atomic Absorption Spectroscopy in which candidates were expected to demonstrate knowledge of AAS as an analytic tool and to apply concepts to the problem posed.

The modal range was 0-5. The following were noted:

(a) very few candidates mentioned that AAS was used to detect minute quantities of elements for part (a);

(b) very few candidates expressed the relationship between absorbance and concentration in part (b);

(c) candidates confused intrapolation and extrapolation in answering part (b);

(d) many candidates were unable to convert ppm to mg and then to g in response to part (c) (ii).

Question 9

Specific Objectives: 2.21, 3.6

Mean 8.98
S.D.: 4.61
Range: 0-18

This item assessed candidates' knowledge and understanding of mass spectroscopy and their ability to apply these understandings to suggest the structural formula of compound X.

Candidates performed satisfactorily on this question with a model range of 10-13.

Note however that:

(a) many candidates wrote the following incorrect equation for (b) (i);

$$M + e \rightarrow M^{+}$$

(b) some candidates included units in answer to mass/charge ratio;

(c) most candidates did not indicate the units of measurement of molar mass;

(d) many candidates omitted the positive charge from the formulae of the fragmented ions.

UNIT 2

PAPER 01

Question 1

Specific Objectives: 2.9-2.12

Mean: 5.06
S.D.: 2.24
Range: 0-10

The modal range for this item on buffer solution – definitions, use of equation and calculation was 5-6 marks.

Candidates produced good definitions of buffer solutions and were able to list the components of a buffer solution. However, many candidates were unable to calculate the pH of the buffer solution when small quantities of acid and alkali were added. Some candidates even produced qualitative descriptions/explanations instead of calculation. (See Appendix 4 for solution)

Question 2

Specific Objectives: 2.13-2.15, 3.3

Mean: 4.07
S.D.: 2.42
Range: 0-9

This question assessed candidates' ability to demonstrate the use of experimental results in the determination of solubility product of Ca $(OH)_2$ at 25°C and their ability to apply theoretical concepts and principles to experimental observation.

The modal range for this item was 3-4 marks. In general part (a) (i) which asked for the written expression for the solubility product of calcium hydroxide and (d) (ii) in which candidates were expected to name "the common ion effect" were well done. Candidates were, however, unable to fully show how the results of the practical activity, such as, burette readings, volume of filtrate and concentration of acid could be used to find the molar

concentrations of OH^- ions and hence Ca^{2+} ions in order to determine K_{sp} $Ca(OH)_2$. (See Appendix 5 for solution)

Question 3

Specific Objectives: 1.1 – 1.7, 1.8

Mean: 7.25
S.D.: 1.90
Range: 2-10

This question required candidates to demonstrate their understanding of the concepts associated with reaction rates.

Candidates performed very well in this item. The modal range was 7-8. The most common errors were that:

(i) some candidates did not provide an explanation for the effect of temperature on reaction rate along with the Boltzmann distribution diagram,

(ii) some candidates labelled the axes as reaction rate vs. reaction time instead of number of molecules/particles vs. energy;

(iii) some candidates wrote rate constant expressions that included the products of the reaction, for example, Rate = $k[SO_2]$ $[CI_2]$.

Question 4

Specific Objectives: 1.10, 1.11

Mean: 3.08
S.D.: 2.45
Range: 0-10

This item examined candidates' knowledge and understanding of trends in the solubility of Group 2 sulphates and their ability to engage in deductive reasoning by applying principles learnt to specific unfamiliar situations.

Most candidates stated the trend in solubility of sulphates correctly. However, many of the explanations did not reflect the depth of understanding required. Candidates were expected to compare variation in lattice energy and hydration energies with the charge in ionic radius.

Question 5

Specific Objectives: 3.2 – 3.6

Mean: 3.25
S.D.: 2.17
Range: 0-9

The candidates' response to this question that tested their knowledge of chemical tests used for the identification of cations and anions was unsatisfactory. The most common errors were that candidates:

(i) identified the cation in (a) (iii) and (iv) as Cr^{3+} instead of Fe^{2+}

(ii) did not indicate that the dichromate (VI) should be acidified in (b) (ii)

(iii) did not know that the reason for addition of HNO_3 before using the Ba $(NO_3)_2$ (aq) is to eliminate anions e.g. CO_3^{2-} or SO_3^{2-}.

Question 6

Specific Objectives: 1.14, 1.15

Mean: 2.99
S.D.: 1.74
Range: 0-8

Candidates' knowledge and understanding of the properties, behaviour and structure of the oxides of Group IV elements were assessed. Candidates were most challenged by parts (a) and (c). Many were unable to explain the trend in stability of the oxide and were unable to write the balanced equation for the reaction of SiO_2 with alkali. Candidates' performance was, however, quite satisfactory when asked to predict patterns and trends from the stimulus material provided.

Question 7

Specific Objectives: 1.5, 4.3

Mean: 6.80
S.D.: 1.88
Range: 1-10

Candidates performed very well on this question which was based on alcohol production and effects of abuse of alcohol. The modal range was 7-8. Many of the candidates who did not perform well focussed on the effects of alcohol on the body without stating the social and economic consequences of the abuse of alcohol. A small number misinterpreted the question (d) and gave consequences of the reduction of use of alcohol by stating that there will be loss of jobs since reduced consumption makes the industry non-profitable.

Question 8

Specific Objectives: 1.8, 1.9, 2.8

Mean: 5.78
S.D.: 2.56
Range: 0-10

Candidates' response to this item that was based on theContact Process in the manufacture of sulphuric acid was just satisfactory with a modal range of 5 – 6.

In general, candidates were quite familiar with the Contact Process. However, a surprising number of candidates wrote that the anhydride (SO_3) should be dissolved in water. Additionally, many candidates did not indicate the reversible nature of the second stage, that is $2S0_2 + O_2 \rightleftharpoons 2S0_3$

Part (d) was not well done by many candidates.

Question 9

Specific Objectives: 2.5, 5.1, 5.2

Mean: 3.58
S.D.: 1.79
Range: 0-10

This question assessed candidates' knowledge of the nitrogen cycle and their ability to use graphical data to identify patterns and relationships and hence to suggest reasons for the relationship identified.

Candidates' performance was in general barely satisfactory with a modal range of 3-4. Many candidates' responses did not suggest that they were aware of the details involved in the processes that constitute part of the nitrogen cycle. For example, candidates stated that the process of nitrification involved the conversion of nitrogen to nitrates but did not include the means by which conversion is achieved, such as, fixation by lightning or by bacteria and many candidates were unable to write the balanced equations.

Most candidates inferred the correct relationship between concentration of hydrocarbons and NO_2 and many provided a satisfactory reason for the relationship identified. Most candidates were able to identify photochemical smog as the environmental effect of high concentrations of NO_2.

PAPER 02

Question 1

Specific Objectives: 2.6 – 2.8

Mean: 4.22
S.D.:1.82
Range: 1-10

Candidates were expected to demonstrate their understanding of acid/base equilibria.

The most common errors were that candidates:

(a) identified A as the strong acid and B as the weak alkali. They did not use the data provided (titration curve) appropriately;

(b) did not indicate a section of the curve that causes a change in pH of $\geq$ 2 units. Some indicated a point on the curve;

(c) gave ranges outside the expected values e.g. from 3 to 7.5 instead of the expected 3.6 – 6.9;

(d) could not provide a satisfactory reason why indicators may be ineffective for specific reaction under study. For example, that methyl yellow changes colour before the end point of the reaction. (See Appendix 6 for solution)

Question 2

Specific Objectives: 1.1, 1.2

Mean: 1.92
S.D.: 1.91
Range: 0-8

This item assessed candidates' knowledge and understanding of the variations in physical and chemical properties of elements in the period Na to Ar.

This question was poorly done. Some candidates:

(i) were unable to distinguish between structure (for example, giant lattice) and bonding (metallic bonds), or they used terms such as giant metallic molecules;

(ii) described the bond between metal cations as ionic;

(iii) gave the names of compounds formed instead of the observation made. For example, they said that sodium chloride was formed instead of white solid.

Question 3

Specific Objectives: 2.3, 3.2

Mean: 4.78
S.D.: 1.92
Range: 0-9

This question was based on water purification and water pollution.

The candidates' performance was fairly satisfactory. Most candidates stated that the water should be put to domestic use, and provided satisfactory reasons for their choice.

Many candidates also correctly stated that a glass container should be used and were able to suggest reagents and correct observation for the identification of Pb^{2+} ions.

Question 4

Specific Objectives: 2.1 – 2.3, 3.1

Mean: 6.58
S.D.: 3.80
Range: 0-16

This item on the principles of chemical equilibrium was quite challenging for the candidates who attempted it.

Many candidates:

(i) were unable to list four characteristics of a system in dynamic equilibrium;

(ii) thought that a catalyst affects the rate of the forward reaction only and therefore alters the position of the equilibrium

(iii) were unable to calculate the amount of EACH gas present in the equilibrium mixture and the value of P. (See Appendix 7 for solution)

Question 5

Specific Objectives: 2.16 – 2.19, 2.21

Mean: 9.08
S.D.: 3.02
Range: 3 – 17

Candidates were assessed on their knowledge and understanding of redox equilibria and their ability to apply these concepts to new but familiar situations.

Many candidates were able to define the term 'standard cell potential' and to suggest at least two adjustments to the apparatus, for example, the use of a salt bridge and the removal of the

battery replaced by a voltmeter. Part (e) was also satisfactorily done. However, many candidates were unable to perform the calculations required in (c) (ii), to suggest the effect of replacing 1.0 mol dm^{-3} Fe SO_4 with 2.0 mol dm^{-3} Fe SO_4.

Question 6

Specific Objectives: 1.16 – 1.19

Mean: 10.53
S.D.: 2.98
Range: 2-17

This question was based on properties of Group VII elements.

Candidates' performance in this question was satisfactory.

Many candidates demonstrated satisfactory performance on parts (a), c (ii), (d) and (e). However, most were unable to describe the reaction of the halogen with hydrogen and explanations were in general at a fairly superficial level.

Question 7

Specific Objectives: 1.21 – 1.25

Mean: 12.76
S.D.: 3.24
Range: 3-19

Candidates were expected to demonstrate knowledge and understanding of the first row transition elements and to use data provided to classify elements as transition elements or as s-block elements.

In general, candidates demonstrated good knowledge and understanding of the characteristics of transition elements and the electronic configurations. Explanations for the differences in colour, however, were not well done.

Question 8

Specific Objectives: 2.7, 3.5, 3.6

Mean: 8.60
S.D.: 2.39
Range: 0-18

This question was based on the chemistry of ozone (chemistry of the physical environment).

Candidates' performance was barely satisfactory with modal range of 6-9.

Many candidates could not write the balanced equation required for (b) and (d). The candidates' responses to (e) were satisfactory. They mentioned effects such as skin cancer

and cataracts, sea-level rise and loss of coastline, and the better responses included the economic effects, such as, increase in insurance premium for persons living in low-lying areas, to slow the impact of human life.

Question 9

Specific Objectives: 1.4, 4.2, 4.4

Mean: 8.57
S.D.: 3.47
Range: 0-17

This item was based on the industrial manufacturing of ammonia, chemistry in industry and the uses of ammonia in agriculture.

Responses to this question were satisfactory. Candidates experienced the most difficulty in answering part (b) – writing balanced equations, for example,

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$$

OR

$$CH_{4(s)} + 2H_2O \rightleftharpoons CO_{2(g)} + 4H_{2(g)}$$

AND

Part (c) $$2H_{2(g)} + [O_2 + 4N_2] \rightleftharpoons 2H_2O_{(g)} + 4N_{2(g)}$$

APPENDIX 1

UNIT 1

PAPER 01

Question 7

(a) Calibration – The process of marking off the scale or to determine or mark the scale on an instrument.

(b) Accuracy – the degree to which a determined value is close to the true or most probable value

Precision – the agreement between a number of measurements of the same quantity

(c) (i) $\sum x / 10 = 25.010 \text{ cm}^3$

(ii) $((\sum x - x)^2 /9)^{1/2} = 0.004$

(d) $25.010 \pm .004$

(e) Temperature
Density is temperature dependent

APPENDIX 2

UNIT 1

PAPER 01

Question 8

(a) Illustration show

- energy gaps between sigma, p, bonding and antibonding orbitals
- possible electron transition

(b) Short wavelength and High frequency/High energy

(c) Aromatic ring

Carbonyl group

(d) (i) Using $A = E\,C\,L$

$C = 0.85/12000 \times 1$

$C = 7.1 \times 10^{-5}$ mol dm^{-3}

(ii) Mass concentration = $7.1 \times 10^{-5} \times 152$ mol dm^{-3} g $mol^{-1} = 1.1 \times 10^{-2}$g dm^{-3}

(iii) Mass of P in 1000 $cm^3 = 101 \times 10^{-2}$g

Mass of P in 10 cm^3 $= 1.1 \times 10^{-2} \times \frac{10}{1000}$ g

$= 1.1 \times 10^{-4}$g

Mass of sample = 10g

% of P in sample = $\frac{1.1 \times 10^{-4}}{10} \times 100$

$= 1.1 \times 10^{-3}$%

APPENDIX 3

UNIT 1

PAPER 02

Question 3

(a) OH: 3400 cm^{-1}

C = O: 1750 cm^{-1}

(b) Symmetric or asymmetric stretch

e.g.

bending
e.g.

(c) $3400 = 1/\lambda$

$\lambda = 2.941 \times 10^{-4}$cm
$= 2.941 \times 10^{-6}$ m
$\lambda = 2.941 \times 10^{-6} \times 10^{6}$
$= 2.941$ μm

(d) Other possible absorptions

C = C	stretch
C – O	stretch
C – H	(saturated) stretch
[C – H]	(unsaturated) stretch

(e) Small mass of sample ground to a smooth paste in liquid nujol Paste placed between NaCl plates for IR analysis

OR

Small mass of sample mixed with KBr solid homogeneously pressed into a disc for IR analysis

APPENDIX 4

UNIT 2

PAPER 01

Question 1

(a) A buffer solution such as acetic-acid-sodium acetate solution is one whose pH changes only very slightly upon addition of small amounts of either an acid or base

(b) (i) Weak acid and its conjugate base(one of its salts)

or

(ii) weak base and its conjugate acid (one of its salts)

(c) (i) $C_2H_3O_2^- + H_3O^+ \rightarrow HC_2H_3O_2 + H_2O$

(ii) $HC_2H_3O_2 + OH^- \rightarrow C_2H_3O_2^- + H_2O$

(d) (i) $C_2H_3O_2^- + H_3O^+ \rightarrow HC_2H_3O_2 + H_2O$

original buffer	1 x 0.5M		1 x 0.2M	
	= 0.5 mol		0.2 mol	
add change	- 0.005 mol	0.005 mol	+	0.005 mol
final buffer	= 0.495 mol		0.205 mol	
mol	= 0.495M		0.205M	

$$pH = PK_a + \log \frac{[C_2H_3O_2^-]}{HC_2H_3O_2} = 4.76 + \log \frac{0.495}{0.205} = 5.14$$

(ii) $HC_2H_3O_2 + OH^- \rightarrow C_2H_3O_2^- + H_2O$

original buffer	1 x 0.2m		1 x 0.5m	
	= 0.2 mol		= 0.5 mol	
add change	- 0.005 mol	0.005 mol	+	0.005 mol
final buffer	= 0.195 mol		0.505 mol	

$$pH = pK_a + \log \frac{[salt]}{[acid]} = 4.76 + \log \frac{0.505}{0.195} = 5.17$$

APPENDIX 5

UNIT 2

PAPER 01

Question 2

(a) $K_{sp} = [Ca^{2+}] [OH^-]^2$
(N.B. award no marks if conc^N [ ] not given)

(b) (i) No. of moles OH^- ≡ no. of moles H^+

$$= \frac{\text{buretter reading x } 0.1}{1000}$$

(ii) Molar conc^N OH^- ≡ $\frac{1000}{25}$ x ans to b (i)

(iii) Molar conc^N Ca^{2+} = 1/2 ans to b (ii)
Ksp = $[b(ii)]^2$ $[b(iii)]^2$

(c) $[Ca^{2+}] = x$ ∴ $[OH^-] = 2x$
⇒ $4x^3 = 5.5 \times 10^{-6}$
Either $x = \sqrt[3]{\frac{5.5 \times 10^{-6}}{4}}$
OR Ans = 1.1×10^{-2} mol dm^{-3}

(d) (i) White ppt
(ii) Common ion effect
(iii) EITHER:

Candidates give the equibibrium: $Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}{}_{(aq)} + 2OH^-_{(aq)}$ and explains that :- (1)

Increasing $[Ca^{2+}]$/Addition of $CaCl_2$ pushes equilibrium position to Left (1) ∴ ppt of $Ca(OH)_2$

N.B. In this explanation the eq. must have states

OR

Increasing $[Ca^{2+}]$/Addition of $CaCl_2$ decreases $[OH^-]$ and the only way to accomplish this is for OH^- to come out of soln by precipitating $Ca(OH)_2$

APPENDIX 6

UNIT 2

PAPER 02

Question 1

(a) A = any named weak alkali e.g. aq. Ammonia
B = any named strong Monobasic acid e.g. HCl

(b) Candidates must clearly indicate the vertical portion of graph, that is, 3.6 – 6.8

(c) (i) pH @ Equivalence pt
5.2 is correct value for graph given

(ii) Vol @ 5.2/candidates value should be 25.0 cm^3

(d) (I) Methyl Red
(ii) (a) Red

(b) Orange/Peach

(iii) Either Methyl Yellow – Indicator Changes Colour Before End Pt.

or Phenolphtalein – change colour } end point will pass and indicator will or Bromothymol Blue not

APPENDIX 7

UNIT 2

PAPER 02

Question 4

(a) 4 Characteristics

- Macroscopic properties e.g. vols. of liquid, amounts of substances are constant under the stated conditions of Temp. and Pressure
- Microscopic processes continue to occur but are in balance/Rate $_{forward}$ = Rate$_{backward}$
- Equilibrium can be achieved from either direction
- Equilibrium can be achieved only in a CLOSED system/there is no loss or gain of materials to or from the surroundings

(b) (i) - V_2O_5 has NO EFFECT on position of eq.

- Catalysts increase both the rate of forward and backward reactions equally

(ii) - Increased temperature DECREASES equilib. concentration SO_3

- Forward reaction is exothermic and increases strain on system/ Backward reaction is favoured as it is endothermic and will absorb added heat. / Rate $_{backward}$ increased more than 'Rate $_{forward}$

(c) (I) $K_p = \dfrac{P^2_{SO_3}}{P^2_{SO_2} \text{ x } P_{O_2}}$

(ii) Amt. SO_3 $= \dfrac{90}{100}$ x 2 mol $=$ 1.8 mol

Amt. SO_2 $= (2.0 - 1.8)$ $=$ 0.2 mol

Amt. O_2 $= [2.0 - (1/2 \text{ x } 1.8]$ $=$ 1.1

(c) (iii) $PSO_2 = \dfrac{0.2}{3.1}$ p

$PO_2 = \dfrac{1.1}{3.1}$ p

$PSO_3 = \dfrac{1.8}{3.1}$ p

(iv) 200 atm^{-1} $= \underline{\left(\dfrac{1.8P}{3.1}\right)^2} = \dfrac{(0.58P)^2}{.065P^2}$ x 0.35P

$$\left(\frac{0.2P}{3.1}\right)^2 \text{ x } \frac{1.1}{3.2}\text{P}$$

$$= \frac{228}{P}$$

$\therefore$ P = 228/200 = 1.14 atm

Answer must have units

(c) - $K_p = 200\ atm^{-1}$
- Eq constant same because Temp. is same (420°C)