C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

REPORT ON CANDIDATES' WORK IN THE SECONDARY EDUCATION CERTIFICATE EXAMINATION

MAY/JUNE 2011

CHEMISTRY
GENERAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

The overall performance of candidates in the 2011 examination was not markedly different from previous sittings. Candidates performed best on Questions 1 and 2. Although performance on some topics such as organic chemistry continues to be poor, there were no questions on which some candidates did not obtain full marks. From year to year, the report on performance in the CSEC examination highlights the areas that candidates seem to find difficult as well as the kinds of errors that they make. Yet, these weaknesses persist. This report again serves to highlight the strengths and weaknesses in candidates' performance in the examination. Teachers and students are encouraged to use the information presented here to self-assess and so better prepare for the examination.

Factors Contributing to Poor Performance

Weakness in discriminating among concepts

- Far too many candidates continue to confuse related concepts, terms that may sound alike or those that may have a different meaning from everyday common usage. These include concepts such as corrode and corrosive; corrosion and rust; metals, non-metals and their ions such as iodine and iodide; glowing and lighted splint and cathode and anode. In a number of instances, terms were used rather loosely, completely distorting the overall meaning of the idea being communicated. This was very evident when definitions of electrolysis and anaerobic fermentation were given. The point made in previous reports is worth repeating here. Teachers should engage students in developing a deep and enduring understanding of concepts by using strategies that help students to connect ideas and understand principles. Classroom conversations on concepts should be encouraged and the correct use of terms during classroom conversation be the norm. Many candidates lost Knowledge and Comprehension (KC) marks for careless or incorrect use of these terms.
- The language of chemistry also posed problems for some candidates. Far too many candidates confused calcium hydroxide with calcium carbonate. Many showed limited appreciation for the balancing of ionic equations where both the charge and the number of ions need to be balanced. Candidates wrote terms such as 'kill' or 'destroy' when referring to the denaturing of protein molecules.

Misunderstanding of concepts linked to practical procedures

- Candidates seemed unfamiliar with some concepts that are usually encountered in practical lessons. The poor performance on Question 5, for example, was linked to limited understanding of what is required in stating a chemical test and what is meant by the term 'observation'.
- Many questions involved a fair knowledge of practical procedures. It was evident from some of the responses that many candidates did not make the connections between what was being asked and the practical activities that they ought to have encountered while preparing for the examination. For example, in Question 1, the reaction between Solution S and excess sodium hydroxide was described as producing "a solution that was soluble in excess".

Difficulty thinking in hypothetical terms

- This was most evident in the responses to Question 5. Many candidates were unable to predict the correct order of the three metals, copper, iron and Metal X. In a number of instances, candidates attempted to identify Metal X. Candidates seem to need additional practice in this level of thinking which will only take place if teachers provide these opportunities in routine classroom assessment. In this regard, use should be made of past examination questions to provide candidates with ample practice.

Writing and balancing equations and interpreting chemical reactions

- It was clear that many candidates have not learnt the correct valencies of common elements and radicals. As a result, formulae were incorrectly written in equations resulting in marks being lost. This was one of the main reasons for the poor performance on Questions 4 and 5.
- Candidates' inability to interpret what is taking place in a chemical reaction was most evident in Question 6. It is possible that the poor performance on Part (c) of Question 6 was also linked to their confusion of iodine and iodide, mentioned earlier in this report.

Reading and Plotting Graphs

- Many candidates need practice with reading the scales of graphs and plotting points accurately.
- The drawing of the line of best fit is also a skill that many candiates have not mastered.

The following sections give details of the performance on specific questions. This section should be read with the actual question paper as reference.

DETAILED COMMENTS

Paper 01 – Multiple Choice

This paper tested Sections A and B of the syllabus in the Knowledge and Comprehension profile. Performance on this paper continues to be steady and satisfactory. The marks ranged from 0 to 60.

The mean score was 55.2 per cent and the standard deviation was 11.23.

Candidates experienced the most challenges with items based on the following objectives:

- A.1.1 – Particulate nature of matter
- A2.8 – Arrangement in periods and groups
- A.6.2 – Ease of ionization (strength of oxidizing power)
- A.6.17 – The differences between oxidizing and reducing agents
- B1.1.9 – Structural isomerism for alkanes and alkenes up to four atoms
- B2.4.1 – Reactivity of metals
- B2.4.2 – Order of reactivity

Paper 02 – Structured Essay

Question 1

Syllabus References: A: 6.18, 6.20, 6.22, 6.25, 6.27, 6.24; B2 7.1, 7.2, 7.3

Part (a) (i) and (ii)

This section was based on an experiment on electrolysis in which current was made to pass through an electrolyte of aqueous copper sulphate using copper electrodes. The mass of copper produced during the experiment was determined by weighing the cathode at specific intervals and subtracting the original mass of the cathode from the mass obtained at these intervals. An incomplete table of the results was included for candidates to complete based on the data presented. Parts (i) and (ii) tested candidates knowledge and comprehension of electrolysis. This question recorded the best overall performance among candidates. Yet, there are still many areas of weakness that were identified.

Candidates' Performance

Several definitions given indicated candidates' misunderstanding of the purpose and principles of electrolysis. Many candidates lost marks because they failed to include two key components — the fact that electrolysis is a chemical process in which the decomposition of the electrolyte takes place and secondly that it is the passage of an electric current through the electrolyte that does this. The following definition given serves to highlight some of the confusion surrounding the purpose of electrolysis as well as how concepts are used incorrectly. "Electrolysis is the process whereby substances are placed, then electrodes to see how the flow of electrons go towards the correct electrode."

Here the notion of electrolysis resulting in decomposition of the electrolyte is missing and 'electrons' instead of 'ions' are migrating to the electrodes. This is an example of the incorrect use of two concepts having to do with charged particles.

Many candidates confused the cathode and the anode. It was evident that they did not make the associations between cathode with cations and anode with anions. Those associations would help candidates to relate the charge of the electrodes to the charge on the ions that migrate to them. This poor understanding might have caused many candidates to write that "the anode attracts positive ions" and "the cathode attracts negative ions" and also that "the cathode is positively charged and the anode negatively charged". Inappropriate terms were also used in describing what happens at the electrodes. For example, some candidates wrote "the cathode collects positive ions and the anode collects negative ions". The use of the word "collect" in this sense is of course misleading as the ions migrate to the respective electrodes. Most candidates were able to score at least one mark for Part (i).

Expected Response

The expected response was that electrolysis is the process by which electrolytes are decomposed by an electric current. Candidates who wrote statements such as *Electrolysis is the process where an electrical current is passed through a compound causing it to split* were also awarded full marks.
Most candidates scored at least one mark for Part (ii). The more popular responses included the charge of the electrode, whether oxidation or reduction occurs there and the type of ions migrating to the electrode during electrolysis.

Part (a) (iii)

Candidates' Performance

Candidates were required to draw a diagram of the circuit used to carry out the investigation and to label the cathode and electrolyte.

While many candidates were able to score at least two marks for this diagram, there were a few who seemingly had no recollection of how to represent the cell or the electrodes. The most common error was to reverse the conventions used to represent the positive and negative terminals of the cell in the circuit diagram. Hence, the cathode was labelled as being connected to the positive terminal and the anode to the negative terminal.

Most candidates correctly identified the electrolyte and represented the electrodes as dipping into the electrolyte. In some cases, candidates labelled the switch as the cathode or the electrolyte and there were a few diagrams where the cell was not included at all.

Expected Response

Full marks were awarded for diagrams in which the electrodes were dipping into the electrolyte and correct labelling of the cathode (connected to the negative terminal of the cell) and the electrolytes.

Part (a) (iv–x)

In this section of the question, candidates were required to complete the table to show the missing values for the mass of the cathode and the mass of copper deposited, plot a graph of mass of copper versus time, and use the graph to predict the mass of copper that would be deposited at 28 minutes. They were also required to calculate the mass of copper that would be deposited during the reaction.

Candidates' Performance

Most candidates managed to score the five marks for completing the table and used the data from the table to accurately plot the five points on the graph. The two points which posed difficulty for candidates were the points at 15 and 25 minutes as these fell between the small squares on the graph paper. Some candidates were very careless in plotting those points and so lost a mark. Many candidates were unable to extrapolate from the graph the mass of copper to be deposited at 28 minutes as they did not have 30 cm rulers to draw the line to get the reading. Some candidates attempted to draw the straight line graph by free hand and still others seemed to estimate what point the line would cross at 28 minutes. Consequently, many candidates gave incorrect values for the mass of copper to be deposited after 28 minutes (Part vi).

The main flaws with the ionic equation for the reaction were

(a) omission of or incorrect state symbols
(b) subtraction of $2e^-$ from the Cu^{2+} ions instead of adding them to produce copper metal.

Most candidates were able to calculate the quantity of electricity passed during the reaction. The main error here was that a few candidates failed to convert minutes to seconds and a few did not know the correct units for the quantity of electricity.

Part (ix) posed the greatest challenge for candidates. Many of them lost one or both marks here. Many candidates tried to use various algorithms for doing the calculation and got stuck as they selected the wrong ones or ended up doing calculations that were not required. Here as well, there was indiscriminate use of units. In a number of instances, candidates failed to take the number of Faradays required to deposit one mole of copper into consideration when solving the problem.

Most candidates knew to use the formula mass of copper to multiply the number of moles from Part (ix) to get the mass of copper.

Expected Response

The procedure given below is only one way of approaching the problem.
Quantity of electricity $= 0.2 \times 20 \times 60 = 240$ C
No. Moles Copper $= 240 / (2 \times 96000) = 1.23 \times 10^{-3}$
Mass of copper $= 64 \times 1.23 \times 10^{-3} = 0.079$ g

Parts (a) (xi) and (xii)

Candidates' Performance

These two sections seemed to have been the most difficult sections in Part (a). Candidates were required to suggest a possible reason for the difference between the theoretical yield as obtained from the calculations and the actual mass of copper as obtained from the experimental data.

Many incorrect responses were given. Among the more popular ones were:

- The presence of impurities
- Experimental error

A fair number of candidates were familiar with the electrolysis of aqueous copper sulphate solution using different electrodes and were able to obtain a mark. However, vague responses such as “graphite is inert and would not take part in the reaction” were not awarded any marks.

Expected Response

Responses such as *the electrodes were not properly dried* or *there were fluctuations in the current passing through the electrolyte* were awarded the mark for Part (xi).

Differences in the reaction at the anode when the copper anode was replaced with graphite electrodes included:

- Oxygen would be produced instead of the formation of copper ions.
- OH^- ions would be discharged.
- No change in the mass of the anode would occur.

Part (b)

This section was based on the qualitative analysis and required knowledge of the test for the nitrate and zinc ions.

Candidates’ Performance

The responses to this section were disappointing as these very common tests were seemingly unfamiliar to many candidates. Far too many candidates lost marks as they were unable to suggest correct observations for the inferences that an acidic gas and the nitrate ions were present.

Common Incorrect Responses

- Gas produced which turned red litmus blue (for the presence of the acidic gas)
- White precipitate insoluble in excess (for the presence of the Zn^{2+} ion)

Expected Responses

The correct responses were:

- Gas produced which turned blue litmus red
- Brown gas produced
- A white precipitate soluble in excess NaOH

<u>Question 2</u>

This question tested syllabus objectives A: 4.1, 4.3, 4.5, 4.7, 5.3

Candidates did fairly well on this question.

Part (a)

This section of the question tested knowledge of the structures and conductivity of three solids: iodine, zinc and diamond. The majority of candidates scored between four and six marks on this section. Only the very weak candidates failed to obtain any marks. Although the question indicated the terms to be used for describing the bonding in the substances, some candidates ignored the categories given and wrote terms such as ‘large covalent’ and ‘covalent’ in describing the structures. These categories were not awarded any marks. A number of candidates classified zinc as ionic instead of metallic.

The correct responses were:

Iodine	simple molecular	does not conduct in the solid state
Zinc	metallic	conducts in solid state
Diamond	giant covalent	does not conduct

Part (b)

Part (b) was based on a comparison of the solubility curves for magnesium chloride and potassium nitrate. Most candidates correctly interpreted the solubility curves and identified magnesium chloride as the more soluble of the two solids at 15^{o}C. While most candidates knew how to determine the mass of potassium nitrate that would be deposited after cooling from 80^{o}C to 20^{o}C, far too many candidates lost marks because they read the graphs incorrectly.

The correct readings from the graph were 14.4 g for the solubility at 80^{o}C and 7.6 g for the solubility at 20^{o}C. The correct answer for the mass of potassium nitrate was therefore 6.8 g, obtained by simple subtraction of the solubility at 20^{o}C from the solubility at 80^{o}C.

The temperature at which the two salts had equal solubility was the temperature at which the two solubility curves intersected. The correct reading was 56.5^{o}C.

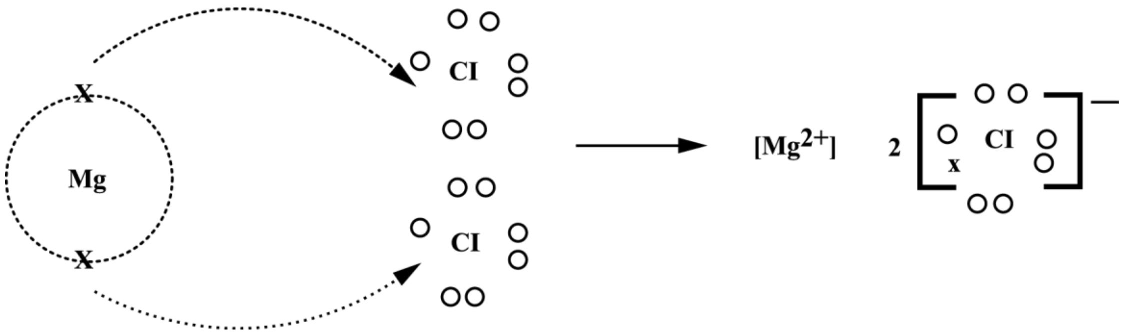
Part (c)

This section required a diagram to show the bonding between magnesium and chlorine. Candidates were expected to deduce that the bonding between magnesium and chlorine was ionic. They were not provided with the atomic numbers of magnesium and chlorine as these are among the first 20 elements of the Periodic Table and candidates are expected to be familiar with them.

The main incorrect responses were:

- Treating magnesium as having a valency of 1 instead of 2
- Treating chlorine as having a valency of 2 instead of 1
- Representing the bonding diagram as covalent instead of ionic bonding
- Failure to show the charged ions formed after magnesium donates the valence electrons to chlorine

The correct dot cross diagram to show the bonding between magnesium and chlorine is given below.



Part (d)

Candidates were asked to use their knowledge of bonding to predict the bonding likely to be present in solid air fresheners and to explain their reasoning.

Most candidates lost marks here. Whereas many candidates correctly identified the bonding as simple molecular, the majority of candidates could not provide a suitable explanation for this. A number of candidates incorrectly identified the bonding as ionic or giant covalent.

Expected Responses

The correct classification was simple molecular. The required explanation included a mark for

- showing understanding that the bonds between the particles were relatively weak
- recognition that the weak bonds would result in the particles escaping and diffusing into the surrounding atmosphere at room temperature.

Hence, responses such as the ones below were awarded full marks.

Simple molecular. This allows them to diffuse easily into the air by breaking the weak bonds found in a simple molecular structure, for example, Iodine.
As simple molecular because bonds can be easily broken to release scent. Giant covalent and ionic lattice are strong bonds and cannot be easily broken as that of simple molecular.

However, responses such as the one below was only awarded two of the three marks as it did not adequately convey the second bulleted point above.

I would classify them as simple molecular as the molecules are moulded into solid and are held by weak bonds like Van der Waals' bonds which are easily broken.

<u>Question 3</u>

Syllabus References: B1: 3.4, 3.5, 3.6, 4.2, 4.3, 4.7

Candidates were tested on anaerobic fermentation, alkaline hydrolysis of esters, saponification and synthetic detergents, and addition and condensation polymerization.

Part (a) (i)

In this part, candidates were required to define *anaerobic fermentation.*

Candidates' Performance

Less than 50 per cent of the candidates gave the correct definition of *anaerobic fermentation*.

Common Incorrect Responses

- When yeasts respire anaerobically
- Respiring without the use of oxygen
- The production of wine/ethanol using yeast

Expected Response

Anaerobic fermentation is the conversion of sugars to smaller molecules like ethanol and carbon dioxide. It takes place in the absence of oxygen.

Part (a) (ii)

In this part, candidates were required to give one reason why high temperatures are not suitable for anaerobic fermentation.

Candidates' Performance

Many candidates were unaware that it was the enzymes in the yeast cells that were responsible for converting the sugars to ethanol and carbon dioxide, or that the enzymes were proteins and therefore would be denatured at elevated temperatures, and lose their function. Some candidates gave partially correct responses stating that enzymes operate at an optimum temperature but did not mention what would happen if the optimum temperature was exceeded.

Common Incorrect Responses

- High temperatures can kill the yeast.
- High temperatures can kill the enzymes.

Expected Response

Temperatures in excess of $40^{o}C$ will denature the enzymes (proteins) in the yeast, which makes them inactive.

Part (b)

Candidates were required to draw the *fully displayed* structures of the products of the alkaline hydrolysis of ethylpropanoate. Esters are formed from the condensation reaction between a *carboxylic acid* and an *alcohol*, with the elimination of a molecule of water. Hydrolysis is the reverse of this process, where the ester produces the carboxylic acid and the alcohol.

Candidates' Performance

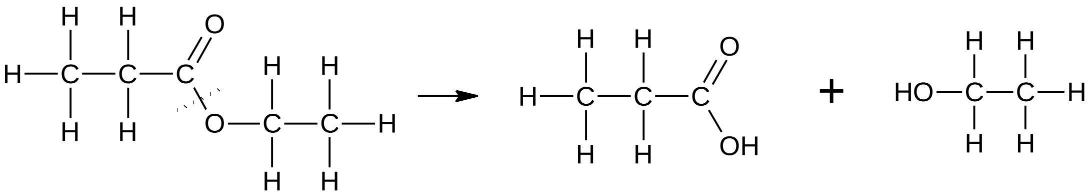
Less than 50 per cent of the candidates gave the correct structures for propanoic acid and ethanol.

Common Incorrect Responses

- Drawing structures for an acid and water instead of acid and alcohol
- Drawing condensed structures instead of fully displayed structures
- Not drawing all the hydrogen atoms on the functional groups
- Drawing HO instead of OH as the functional group of alcohols
- Drawing a carbon atom with five or six bonds around it, instead of four

Expected Responses

The hydrolysis reaction is shown below, where the single bond between the carbon and the oxygen is broken as shown and the elements of water are added, the OH onto the carbon and the H onto the oxygen.



Ethyl propanoate Propanoic acid Ethanol

Part (c)

In this part, candidates were required to name one by-product of the saponification of fats and oils, and to state one disadvantage of synthetic cleaning agents over soaps.

Candidates' Performance

The majority of candidates did not appear to understand the meaning of the term 'by-product', giving answers which indicated that they thought that by-product meant what the soaps/detergents could be used to make. Very few candidates gave the correct by-product or were able to give an advantage.

Common Incorrect Responses

Some incorrect responses showed some confusion, or were vague. Some examples are:

- Scum was formed by the detergent.
- The detergent was difficult to lather.
- Detergents 'pollute the environment'.
- Detergents were 'biodegradable'.

Incorrect by-products:

- Water
- Scum

Expected Responses

The by-product is glycerol and two disadvantages are that synthetic cleaning agents can cause excessive foaming and they are not biodegradable. This means that they will stay in the environment for a very long time.

Part (d) (i)

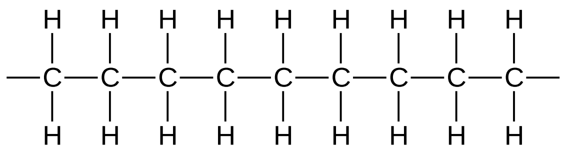
Candidates were provided with the fully displayed structure of propene, and were required to draw the partial structure of the polymer formed from propene, using three units of the monomer to demonstrate the answer.

Candidates' Performance

It was evident that some candidates did not read this question properly as they either used the incorrect monomer in their diagrams or used the incorrect number of repeat units (2 or 4 instead of 3).

Common Incorrect Responses

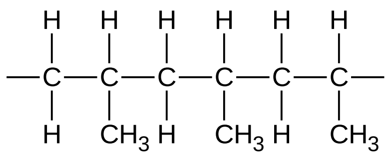
In one common incorrect response, candidates had the three carbon atoms of propene connected in a line.



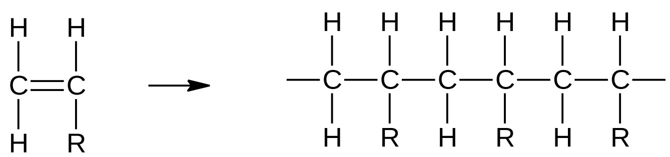
The above structure is that of polyethene.

Expected Responses

The correct partial structure of the polymer is:



For alkene type monomers, the carbon atom bearing the R-group is referred to as the *head* and the other carbon atom (the one bearing the two hydrogen atoms) as the *tail*. In the polymer chain the monomers are joined in a *head-to-tail* fashion so that the structure is as shown below. In propene and polypropene the R-group is CH_3.



monomer polymer

Part (d) (ii)

In Part (d) (ii), candidates were required to state the name of the type of polymerization that 3-aminopropanoic acid would undergo, and give the general name of the polymer.

Candidates' Performance

The majority of candidates correctly stated that the type of polymerization is *condensation polymerization*, but did not give the correct *general name* for the type of polymer. Some candidates assumed that the question was referring to the propene monomer and gave answers which were propene related. Some candidates assumed that since 3-aminopropanoic acid is an amino acid then the polymer formed would be a protein. Proteins are formed from the condensation of several *naturally occurring* amino acids.

Common Incorrect Responses

The most common incorrect response for the type of polymerization was:

- Addition polymerization

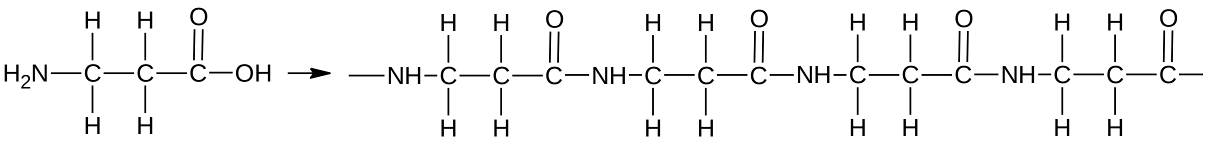
Common incorrect responses for the type of polymer formed were:

- Polypropene
- Polyami**n**e
- Protein
- Polypeptide

Expected Responses

The type of polymerization reaction that 3-aminopropanoic acid undergoes is condensation polymerization, and the general name for the type of polymer is polyamide. The reaction is between the amino group of one monomer and the carboxylic acid group of another monomer, a molecule of water is eliminated and an *amide* bond/link is formed, hence the name *polyamide*.

The structure of the polyamide polymer was not required but it is shown here in an attempt to clarify the answer. The monomer and the partial structure of the polymer are shown below.



Amino acid (monomer) polyamide (polymer)

Part (d) (iii)

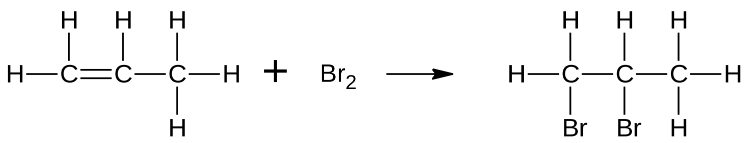
In this part, candidates were required to outline a chemical test that can be used to distinguish between propene and its polymer.

Candidates' Performance

Many candidates correctly stated that propene would react with bromine (in an addition reaction) and would therefore decolourize a reddish solution of bromine dissolved in an organic solvent, or bromine in water. Some candidates also correctly stated that propene would decolourize a purple solution of acidified potassium permanganate ($KMnO_4$). Many candidates gained one mark for giving a correct reagent, but failed to get the other mark by *not* stating how the reagent is used to distinguish between propene and its polymer.

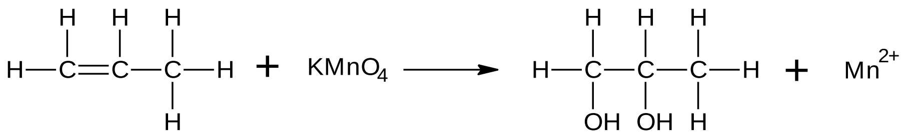
Expected Responses

Alkenes react with bromine, which is red in colour, to give the colourless 1,2-addition product, where the two bromine atoms are added on either side of the double bond, as shown in the following equation:



Propene bromine (red) 1,2-dibromopropane (colourless)

In general, alkenes react with purple acidified potassium permanganate solution to give the 1,2-dialcohol and the almost colourless Mn^{2+}(aq) ion. 1,2-propanediol, which is also colourless, is the product in this case.



Propene Potassium Permanganate 1,2-propanediol manganese(II) ions

Many candidates did not attempt Parts (d) (i)–(iii).

<u>Question 4</u>

Syllabus References: A 8.2, 8.3, 6.8, 6.10; B2: 6.1, 6.2

Part (a) (i)

This section tested knowledge of the reactions of acids with carbonates and metals and required the writing of equations to describe these reactions. In addition, it tested knowledge of the chemical tests for carbon dioxide and hydrogen gas**.**

Candidates' Performance

Given the familiar chemicals used in this question, it was very disappointing to read some of the responses obtained. Many candidates demonstrated very little knowledge of these reactions and were careless in their answers. It was clear that they knew that acids react (a) with carbonates to produce a salt, carbon dioxide and water and (b) with active metals to produce hydrogen gas and a salt. The question specifically asked for the 'expected observations' for the reactions and 'a chemical test' to identify any gas that would be evolved. Marks were lost in this section because of three main reasons.

- Many candidates missed the word 'observation' and stated instead the expected products of the reactions.
- In describing the test for the gases, either the incorrect reagents / conditions were used or there was no description of what results would be obtained for a positive test.
- Incorrect chemical formulae were used.

Many candidates were more familiar with the reaction between potassium carbonate and dilute nitric acid and hence more errors occurred in the attempt to construct the equation for the reaction between zinc and dilute nitric acid.

Common Incorrect Responses

- Test for hydrogen with a glowing splint instead of a lighted splint
- Giving the correct test reagents for the gas but not stating the results
- Formula for lime water given as $CaCO_3$ instead of $Ca(OH)_2$
- Formula for zinc nitrate given as $ZnNO_3$ instead of $Zn(NO_3)_2$
- The litmus test given as the confirmatory test for carbon dioxide
- Recording the observation as “hydrogen gas evolved or carbon dioxide evolved” instead of vigorous effervescence or bubbles formed and zinc metal/potassium carbonate disappears

Expected Responses

Acceptable observations for both reactions were *rapid effervescence of a colourless gas*.

The test for carbon dioxide involves passing the gas through lime water. A white precipitate confirms the gas. The test for hydrogen involves testing the gas with a lighted splint. Hydrogen will put out the splint with a ‘pop’.

Part (a) (ii)

This part of the question tested knowledge of the preparation of a soluble salt such as potassium or zinc nitrate.

Candidates’ Performance

Many candidates scored at least one mark for this question as they included the process of crystallization of the filtrate in their response. However, the procedures recorded indicated that many candidates did not have a clear understanding of how to prepare soluble salts.

Common Incorrect Responses

- The salt was treated as an insoluble salt and ionic precipitation used as the method for preparing it.
- ‘Solutions’ were filtered to obtain a filtrate.
- Filtrates were evaporated to dryness instead of concentrating the filtrate and allowing the crystals to form.

Expected Responses

The correct procedure for preparing a solid sample of the salt is as follows:

- Add excess solid (metal or carbonate) to the acid.
- Filter the mixture to remove the excess metal or carbonate.
- Heat the filtrate to evaporate most of the liquid and allow crystals to form.
- Filter to remove crystals and dry.

Part (b)

This question tested knowledge of the factors that cause rusting.

Candidates' Performance

Rusting was generally well understood but the uncertainty about the conditions for rusting led to incorrect answers. Some responses were ambiguous. An example of this was "no corrosion is expected in A and B but a small amount will be visible". This response was not awarded any marks. Other candidates referred to the rate of rusting instead of whether or not rusting would take place.

Expected Responses

The correct responses were that there would be no rust formed in A and B as in the case of A no oxygen is present and in the case of B, no water is present. Rust would be formed in C as both water and oxygen would be present.

<u>Question 5</u>

Syllabus References: B2: 5.1, 4.1, 4.2, 5.2: A: 3.3

In this question, candidates were required to (a) determine the relative reactivity of an unknown Metal X, when compared to iron and copper, (b) explain the properties and uses of alloys (c) use the mole concept in a calculation.

Part (a)

In this part of the question, two experiments were described.

Experiment 1: A piece of Metal X, when placed in a blue solution of copper(II) sulphate, became copper plated, and the solution gradually became colourless.

Experiment 2: There was no visible change when a piece of Metal X was placed in a solution of iron(II) sulphate.

Part (a) (i)

Candidates were required to place the three metals (X, iron and copper) in order of their appearance in the reactivity series, starting with the most reactive.

Candidates' Performance

Many candidates had two of the metals in the correct order, but less than 50 per cent of them had all three metals in the correct order.

Expected Responses

The correct order with the most reactive metal placed first is: Iron > Metal X > Copper.

Metal X displaced copper metal from a solution of copper(II) ions, therefore Metal X is more reactive than copper (that is, Metal X > Copper). Metal X does not displace iron metal from a solution of iron(II) ions, so metal X is less reactive than iron (that is, Metal X < Iron, or, Iron > Metal X). Putting both pieces of information together gives: Iron > Metal X > Copper.

Part (a) (ii)

In Part (a) (ii), candidates were required to write an ionic equation, *including state symbols,* for the reaction between Metal X and copper(II) sulphate.

Candidates' Performance

Most candidates attempted to write the full equation instead of the ionic equation. In many cases, where the ionic equation was given the state symbols were absent.

Common Incorrect Response

$$X(s) + CuSO_4(aq) \rightarrow XSO_4(aq) + Cu(s)$$

Expected Response

The ionic equation for the reaction between Metal X and copper(II) sulphate is

$$X(s) + Cu^{2+}(aq) \rightarrow X^{2+}(aq) + Cu(s)$$

Part (b) (i)

In this part, candidates were required to define an alloy.

Candidates' Performance

Many candidates correctly indicated that an alloy is a mixture of metals. However, many of them stated that an alloy consisted of one or two metals.

Common Incorrect Responses

- An alloy is a mixture of two metals or non-metals.
- Some candidates confused alloys with isomers, allotropes and isotopes.

Expected Response

An alloy is a mixture of two or more metals.

Part (b) (ii)

In this part, candidates were required to give the name of the alloy of copper and aluminium.

Candidates' Performance

The majority of candidates came up with one of the names of the several alloys of copper and aluminium.

Common Incorrect Responses

Many candidates did not give the correct spelling of the alloy.

Expected Responses

The alloys are Duralumin, Dyraluminium, Duraluminum, Dural.

Part (b) (iii)

Candidates were required to state two properties of the alloy, named in Part (b) (ii), that make it a good choice for use in the aircraft industry.

Candidates' Performance

A number of candidates incorrectly stated that the alloy is less corrosive, when they meant to say that the alloy is more resistant to corrosion. Some candidates also stated that the alloy is resistant to rusting, again, meaning resistant to corrosion. (Iron rusts, and so *rust* or *rusting* should be reserved for use *only* when referring to iron or alloys of iron).

Common Incorrect Responses

Many candidates gave responses that were not relevant to the aircraft industry: shiny, malleable, good electrical conductivity.

Expected Responses

The two important properties of aluminium are that it is resistant to corrosion and it has a low density (that is, light).

Part (b) (iv)

In this part, candidates were required to list two other uses of this alloy.

Candidates' Performance

Most candidates were able to get the two marks. The marks were awarded for any reasonable suggestions for using the alloy.

Expected Responses

Uses for the alloy include saucepans, window frames, drink cans.

Part (c)

This part required candidates to do a mole concept calculation based on the given equation:

$$2NH_3 + 3CuO \rightarrow 3Cu + 3H_2O + N_2$$

They were required to calculate the mass of copper produced when 0.12 dm^3 of nitrogen is produced at temperature and pressure.

Candidates' Performance

Many candidates had difficulty with the mole ratio, probably because both of the materials that are relevant to the calculation appear on the same side of the equation. Some candidates incorrectly used a mole ratio of 2:3, which is for ammonia and copper. Some candidates used the mole ratio of 1:3 between N_2 and Cu.

Expected Responses

The steps in the calculation are outlined below, one mark is awarded for each step.

Number of moles of nitrogen = $\frac{\mathbf{0.12\ dm^3}}{\mathbf{24\ dm^3\ mol^{-1}}}$

The mole ratio is 1 N_2 : 3 Cu

Number of moles of copper = $\frac{\mathbf{0.12\ dm^3}}{\mathbf{24\ dm^3\ mol^{-1}}}$ x 3

Mass of copper =($\frac{\mathbf{0.12\ dm^3}}{\mathbf{24\ dm^3\ mol^{-1}}}$ x 3) x 64 g mol^{-1} = 0.96 g

Question 6

Syllabus References: C1: 1.2, 1.6, 1.8, 1.9

In this question, candidates were examined on the denaturing of proteins by heat, the action of commercial and natural tenderizers on meat, the effect of heat on the Vitamin C content of a sample of orange juice, and the reducing properties of Vitamin C.

Candidates' Performance

In general, candidates performed poorly on this question, with an average mark of 4.3 out of 15. Fourteen per cent of candidates scored eight marks or more on this question. The mode was three marks.

Part (a)

In this part, candidates were required to give the reason(s) why protein powders, used as diet supplements, were mixed with cold or lukewarm water instead of boiling water.

Candidates' Performance

The majority of candidates got one of the two marks by indicating that the proteins would be denatured by the boiling water, but failed to state that denaturing would make the protein insoluble.

Common Incorrect Responses

- Hot water will damage or kill the protein.
- Heat would denature the enzyme.
- Protein would lose its nutritive value.
- The protein would no longer be able to carry out its function.

Expected Responses

Hot water will cause the proteins to be denatured which makes them insoluble.

Part (b) (i)

In this part, candidates were required to explain how natural or commercial tenderizers work when used to tenderize meat.

Candidates' Performance

Many candidates were able to get only one of the three marks.

Common Incorrect Responses

A number of candidates misunderstood the question and referred to the tenderizing of meat on the *commercial scale*, using instruments like the pressure cooker, the meat mallet and the meat grinder. Some incorrect responses were:

- Commercial tenderizers like the pressure cooker cook the meat at high temperatures.
- Beat the meat with a hammer to break up the strands.

Expected Responses

Tenderizers contain enzymes. These enzymes hydrolyze the amide linkages between the amino acids of the protein, breaking the long strands into smaller ones.

Part (b) (ii)

In this part, candidates were required to list one advantage and one disadvantage of using commercial tenderizers over natural tenderizers.

Candidates' Performance

A number of candidates obtained one of the two marks by correctly stating that commercial tenderizers work faster than natural tenderizers. The majority of candidates were unable to state a disadvantage of commercial tenderizers.

Common Incorrect Responses

- Advantage – Natural tenderizers get the meat very soft.
- Disadvantage – Commercial tenderizers do not soften the meat as well as natural tenderizers.
- Disadvantage – Commercial tenderizers do not soften the meat completely.
- Disadvantage – Commercial tenderizers are more expensive.

Expected Responses

Advantages – Commercial tenderizers usually work faster than natural tenderizers. They are always readily available, because they are not seasonal.

Disadvantages – There are health related concerns with using substances which are 'foreign' to the human body. Commercial tenderizers can affect the taste of food, possibly giving 'off' flavours.

Part (b) (iii)

In this part of the question, candidates were required to suggest why baking soda, $NaHCO_3$, can be used to tenderize meat.

Candidates' Performance

This part was very poorly done: the majority of candidates were unable to give the reason why baking soda can be used to tenderize meat. They stated that the baking soda tenderized the meat (repeating the question) but did not explain the process.

Common Incorrect Responses

- It is an acid and breaks the links between proteins.
- It softens the meat.
- It also breaks down protein.
- The hydrogen present assists the hydrolysis of proteins.

Expected Responses

Baking soda, $NaHCO_3$, is basic. Therefore, it furnishes hydroxide ions when it comes in contact with water. These hydroxide ions are able to attack and break the amide link in the proteins. This process is known as *base hydrolysis*.

Part (c)

In this part, two identical samples, A and B, of orange juice were analysed for their Vitamin C content, after Sample B was boiled and allowed to cool. Both samples were titrated with an iodine solution using starch as indicator. Candidates were required to (i) state the colour change at the end-point of the titration in both cases, (ii) state, with explanation, which sample would require the larger volume of iodine solution, and (iii) explain with reference to the oxidation number of iodine, whether Vitamin C is acting as an oxidizing agent or a reducing agent.

Part (c) (i)

Candidates' Performance

The majority of candidates correctly indicated that the colour change at the end point of the titration would be blue-black. (In titrations of this type, when the reagent that is reacting with the iodine is used up, the further addition of iodine will result in the excess iodine reacting with the starch indicator to give the blue-black starch-iodine complex).

Common Incorrect Response

- Turned dark

Expected Response

The colour at the end point is blue-black.

Part (c) (ii)

Candidates' Performance

A number of candidates realized that boiling Sample B would cause the amount of Vitamin C in the sample to be reduced, and so would require less iodine solution to obtain the end point. Most candidates were not able to explain how the heat affected the amount of Vitamin C.

Common Incorrect Responses

- Sample B would need more iodine because it was boiled.
- Heat increased the rate of reaction in Sample B so that more iodine would be used.

Expected Responses

Sample A would require the larger volume of iodine solution, because heating Sample B increases the rate of oxidation of Vitamin C by oxygen from the atmosphere. This increased rate of oxidation results in a decrease in the amount of Vitamin C in Sample B.

Part (c) (iii)

Candidates' Performance

A number of candidates correctly stated that Vitamin C is acting as a reducing agent, but did not give the correct explanation in terms of the change in the oxidation number of iodine.

Common Incorrect Responses

- Iodine was reduced.
- Vitamin C is an oxidizing agent.
- The oxidation number of iodine decreased so the vitamin C is acting as an oxidizing agent.
- The oxidation number of iodine increased so the vitamin C is acting as a reducing agent.

Expected Responses

Vitamin C is a reducing agent since it causes the oxidation number (O.N.) of iodine to decrease; that is, the O.N. of iodine decreases from ZERO in I_2 to –1 in I^-.

Paper 031 – School Based Assessment (SBA)

Planning & Designing Skill

Generally, the standard of the laboratory activities assessed for the skill of Planning and Design (PD) has declined slightly. Some suggested areas of possible improvement include:

- Better problem statements (which should be included in the mark schemes)
- Better stated hypotheses
- More appropriate recording of data to be collected
- Writing of the treatment of results
- Use of appropriate tense

The following are areas where some improvement is still needed:

Scenarios

- Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise, this should also be included in the teachers' mark scheme.
- It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PDs) be found.
- It is not recommended that students be left to generate the problems/scenarios on their own; however, in circumstances where this is done these problems/scenarios should be first vetted by the teacher to make sure that they are testable and chemistry based.

Hypothesis

- The hypothesis should be testable. Consider the following scenario:
  Scenario: Four bottles which had lost their labels are now labelled A, B, C and D. It is suspected that they are a sulfate, chloride, carbonate and a hydroxide. Plan and design an experiment to determine the identity of these solutions.
  A non-testable hypothesis would be: "the identification of four solutions that have lost their labels"
  A testable hypothesis would be: *The solutions are A — sulfate, B — carbonate, C — chloride and D — hydroxide.*
- As much as possible, the manipulated variable should be included in the hypothesis.
- The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used in the experiment should be outlined in the hypothesis.

Aim

- Students should be encouraged to specify the method or technique to be employed in the experiment.
- The aim must relate to the hypothesis as well as the problem statement.

Procedure

- Special attention must be placed on the tense used in the procedure. Students should be taught to write the procedure in the present or future tense, any other tense is unacceptable.

Expected Results/Data to be Collected

- This particular area is not well understood and hence it is recommended that the term ‘data to be collected’ be used rather than ‘expected results’.
- In this section the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis will be recorded.
- The data to be collected may be presented in tabular form or as a description of specific data including units where appropriate.

Some examples:

- When doing a titration, the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to be used as data collected.
- If chromatography is used, then the data collected should include the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin. R_f values should never be used as data to be collected since this is also calculated.

Treatment/Interpretation of Results/Data

- It is recommended that the term ‘results’ be replaced by ‘data’ in the heading in an attempt to make it clear that this section looks at how the data collected will be used at proving or disproving the hypothesis.
- This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

Some examples:

- In a scenario where students are trying to find out which brand of vinegar is more concentrated, the Interpretation of Data could be: *If Brand Y vinegar uses the* <u>*least volume*</u> **(Data to be collected)** *to neutralize x* cm^3 *of base then Brand Y is the* <u>*most concentrated vinegar*</u> **(stated in the aim)**, *and therefore the hypothesis is supported.*
- In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: *if both brands of ink* <u>*contain the same number of components with the same colour and are the same distance from the origin*</u> **(Data to be collected)**, *then* <u>*both brands of ink contain the same dye*</u> **(stated in the aim)** *and therefore the hypothesis is supported.*

Limitations/Precautions/Assumptions

- It is recommended that teachers assist students in distinguishing between these terms. While they can be related, the way that they are stated can make a significant difference.

Sources of error

- This section should not be present in a PD laboratory activity since it refers to an activity that has been carried out.

Other Comments

Teachers are encouraged to observe the following:

- All PD activities should be based on chemical concepts. Scenarios from the Social Sciences, Biology, Physics, Food and Nutrition or any other non-chemistry discipline will not be accepted.
- Students should undertake at least four PD activities over the two-year period. When this is not done students are at a disadvantage.
- Observations, calculations or diagrams should not be included in a mark scheme used to assess PD skills
- PD activities which have been carried out cannot be assessed for PD skills.
- Standard practical exercises which can be obtained from a chemistry text are inappropriate for PD activities.

Some examples include:

- *Plan and design an experiment to determine the effect of concentration on the rate of a reaction.*
- *Plan and design an experiment to determine the products of electrolysis of H_2SO_4 using inert electrodes.*
- *Plan and design an experiment to determine the conditions of rusting.*

Analysis and Interpretation

The Analysis and Interpretation (AI) skill continues to be one of the better assessed skills. However, to ensure continued improvement here are a few points to note:

- Observations, definitions, background information, plotting of graphs and questions which are not directly related to the specific practical should not be assessed under AI.
- Some emphasis needs to be placed on units. In many cases, students used incorrect units and were neither penalized nor corrected.
- Students should be encouraged to show their calculations in a step-by-step manner. This helps to ensure that students understand what is required of them. In addition, calculations involving moles and volumes should be done from first principles using the unitary method. *CXC does not accept the use of the equation $M_1V_1=M_2V_2$.*

Create more explicit mark schemes:

- In the case of volumetric analysis, the concentration of reagents used should be provided in the mark scheme.
- In the case of qualitative analysis, the name of the unknown or the ions expected should also be included in the mark scheme.

Paper 032 – Alternative to SBA

Syllabus References: A: 3.1, 3.3, 5.3, 8.1, 8.3; B2: 1.1, 4.1, 4.2, 7.1, 7.2, 7.3

Question 1

This question tested candidates' knowledge of energetics. Candidates were required to determine the heat change that occurs when solid KNO_3 is dissolved in water. Few candidates were able to gain 16 or more of the 26 marks that were available.

Part (a) required candidates to:

(i) State an apparatus suitable for measuring the 50 cm^3 of water.
(ii) Read and record temperature readings from the thermometers given.
(iii) Calculate the temperature changes that occurred.

Many candidates were unable to state suitable apparatus for measuring an accurate volume of solution. The most common responses were beakers and measuring cups. Appropriate answers were measuring cylinder, burette or pipette. The majority of candidates was able to record accurately the temperature readings, but although an example of calculating the temperature difference was given, many candidates did not follow the instruction and hence did not calculate the temperature change accurately.

Part (b) required candidates to:

(i) Plot a graph of temperature against time.
(ii) Calculate the maximum change in temperature and indicate on the graph how the answer was obtained.
(iii) Determine whether the reaction was exothermic or endothermic with a given reason.
(iv) Calculate the moles of KNO_3 used, the heat change and the molar heat change.

Although the majority of candidates received full marks for the plotting of the graph, there were a few who only plotted the temperatures that they recorded. There were very few candidates who were able to indicate the maximum and minimum points on the graph. In addition, some candidates were unable to differentiate between exothermic and endothermic reactions and in many cases the definitions and explanations did not correspond.

Some candidates could not calculate the relative molecular mass of KNO_3 and others were unable to determine the number of moles present. When calculating the heat change some candidates did not use the correct mass of solvent, in many cases they used the mass of the KNO_3 or the combined masses of the KNO_3 and the solvent. The correct calculation is:

$$\begin{aligned} Q &= m \times c \times \Delta T \\ &= 50\text{g} \times 4.2\ \text{Jg}^{-1}{}^{\circ}\text{C}^{-1} \times 8.2\ {}^{\circ}\text{C} = 1722\ \text{J} \end{aligned}$$

Many candidates were also unable to accurately calculate the heat change that occurred when 1 mole of KNO_3 dissolved in the water. It must also be noted that candidates were unable to handle the units, many of them gave answers without units.

In Part (c), candidates were required to describe how they would prepare a saturated solution at 25 °C, however, it seems that most candidates misinterpreted the question and attempted to prepare a sample of KNO_3. The correct procedure is as follows:

1. Heat water to a temperature above 25 °C.
2. Add, with stirring, an excess amount of solid KNO_3.
3. Cool the solution down to 25 °C.
4. Filter the solution from the crystal.

<u>Question 2</u>

This qualitative analysis item tested Syllabus Objectives B2-7.1, 7.2 and 7.3. Candidates were required to deduce the observations that would be made when various tests were performed on an unknown solid R as well as its aqueous solution. A maximum of 10 marks were awarded for this question.

This question was poorly done. More than 70 per cent of the candidates scored five marks or less in this question and more candidates were awarded no marks for this question than on any other. Many candidates seemed unfamiliar with making observations. Most of them rewrote the test or the inferences rather than the expected observations.

Question 3

This question tested candidates’ planning and designing skill. It was related to Syllabus Objectives B2-1.1, 4.1 and 4.2. Candidates were required to plan and design an experiment to determine which of metals. A or B. is more reactive. The hypothesis, “Metal A is more reactive towards acids than Metal B”, was provided. The question was poorly done. More than 75 per cent of the candidates who attempted the question scored a mark of five or less out of 12.

Most candidates recognized that the two metals had to be reacted with an acid but did not time the metal to be dissolved completely or measure the volume of gas collected within a given time. In addition, some candidates tried to identify the metal, while others did not know what an acid was. This was exemplified by the use of other chemicals such as sodium hydroxide and ethanol. There were some procedures given that did not relate to the hypothesis at all but candidates were able to capture the marks awarded for apparatus since that related to their procedure.

Candidates were not able to extract from their procedure the variables to control and those who did used vague terms such as the ‘amount’ of acid or metal rather than ‘volume’ of acid or ‘mass’ of metal. Identifying the data to be collected also proved difficult for most candidates and in many cases, they did not know how to use the data they wanted to collect to show if the hypothesis was valid or invalid.

Very few candidates were able to identify a possible source of error and although this was dependent on the chosen procedure. It should be noted that sources of errors should be factors over which the candidate has no control and which can affect the results, such as, the reaction time for starting and stopping a stop watch, and not inaccurate measurements which can be easily avoided by the candidate, such as, reading a burette incorrectly.