CARIBBEAN EXAMINATIONS COUNCIL

CAPE® CHEMISTRY UNIT 2

Subject Report with Exemplars

June/July 2021

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

JUNE/JULY 2021

CHEMISTRY
UNIT 2

Table of Contents

INTRODUCTION

Unit 2: Chemical Principles and Applications II is divided into three modules. These modules are

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

Candidates' knowledge of this unit is examined through the following papers.

- Paper 01 — Multiple Choice
- Paper 02 — Structured Essay
- Paper 031 — School-Based Assessment (SBA)
- Paper 032 — Alternative to the School-Based Assessment

Paper 01 comprises 45 compulsory multiple-choice items, which consist of 15 items per module. The paper is worth a total of 90 marks, representing 40 per cent of the total mark for the unit.

Paper 02 comprises three compulsory questions. Each module is the basis of one question. The paper is worth a total of 90 marks, representing 40 per cent of the total mark for the unit.

For Paper 031, candidates must complete laboratory exercises. This component of the exam contributes 20 per cent of the total mark for the unit.

Paper 032 is taken by private candidates. It comprises three compulsory questions which assess candidates' experimental skills.

There was an improvement in the overall performance of candidates in 2021 when compared with 2019 and 2020. Ninety-five percent of the 3329 candidates who wrote the examination earned Grades I–V. There was also a significant improvement in the mean mark on Paper 01 and Paper 02 when compared with 2019.

It is encouraging to see an improvement in the performance of candidates on Paper 01 and Paper 02. However, candidates are underperforming on certain topics and so we are encouraging teachers to teach students about all topics in each unit in detail.

PAPER 01 – MULTIPLE CHOICE

Paper 01 consists of 45 multiple-choice items. Approximately 93 per cent of candidates earned Grades I–IV. Out of a maximum of 45 marks, the mean was 34.71 and the standard deviation 8.20.

PAPER 02 — STRUCTURED ESSAY

Question 1

This question tested syllabus objectives 1.4–1.5, 1.7–1.9 and 2.3–2.5 from Module 1: The Chemistry of Carbon Compounds. The mean was 13.09 and the standard deviation 7.51.

Candidate's Response to Part (a) (i)

(a) (i) Define the term 'structural isomerism'.

Structural isomerism is a type of isomerism in which molecules have the same molecular formula but different structural formulae. **[2 marks]**

Examiner's Comments
The candidate accurately defined the term *structural isomerism*.

Candidate's Response to Part (a) (ii)

(ii) Identify TWO types of structural isomers, giving an example of EACH.

Type 1 Chain Isomers

Example Butane and 2-methylpropane (alkanes)

Type 2 Positional Isomers

Example But-1-ene and but-2-ene (alkenes)

[4 marks]

Examiner's Comments
The candidate provided accurate answers and included appropriate examples. Generally, Part (a) (ii) was not well answered by candidates.

Candidate's Response to Part (b) (i)

(b) (i) Volume of CO_2 = (55 - 35) cm^3 = 20 cm^3

Volume of O_2 used = (70 - 35) cm^3 = 35 cm^3

$C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

10 : 35 : 20

1 : 3.5 : 2 x 2

2 : 7 : 4

$2\ C_xH_y + 7O_2 \longrightarrow 4CO_2 + 6H_2O \div 2$

$C_xH_y + \frac{7}{2} O_2 \longrightarrow 2CO_2 + \frac{6}{2} H_2O$

$x = 2 \qquad 2c + \frac{y}{4} = \frac{7}{2}$ 1

$2 + y/4 = 7/2$

$y/4 = 3/2$

$y = 6$

$C_2H_6 + \frac{7}{2} O_2 \longrightarrow 2CO_2 + \frac{6}{2} H_2O \times 2$

$2\ C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

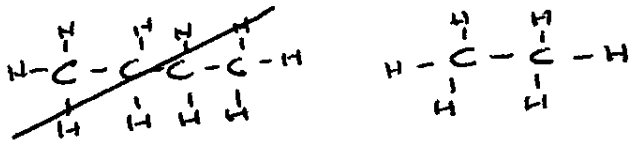
Answer: C_2H_6

Examiner's Comments

The candidate presented the solution using appropriate chemical equations and volumes of gases. The candidate also used well defined algebraic expressions and presented them in an unambiguous manner. The solution was very well developed by the candidate.

Candidate's Response to Part (b) (ii)

(ii) Write the displayed structural formula of P.

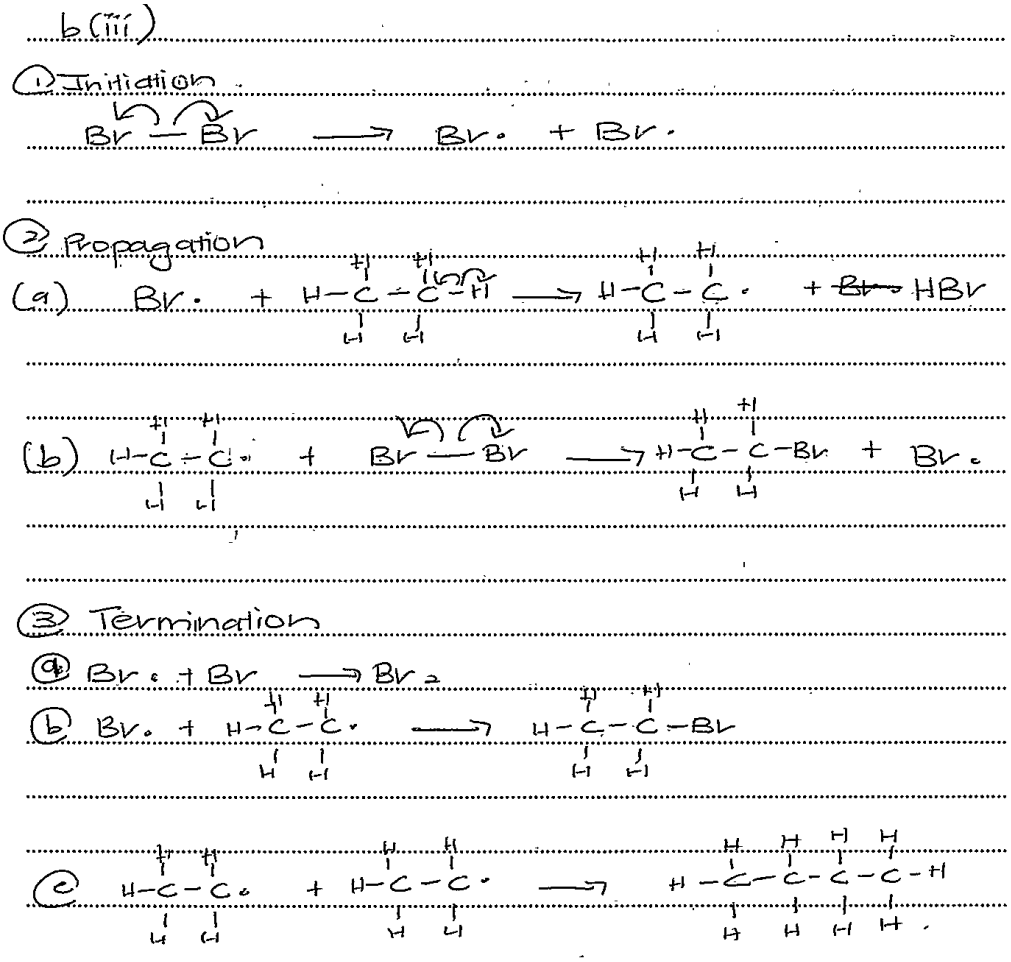


[1 mark]

Examiner's Comments

Generally, candidates accurately represented the structural formula of the molecular formula they obtained in Part (b) (i). In the exemplar, the candidate wrote the displayed structural formula of P accurately.

Candidate's Response to Part (b) (iii)



Examiner's Comments

The candidate excellently represented the reaction mechanism for the reaction of P with liquid bromine, using appropriate notations and equations. The relevant chemical formulae were all correct and the candidate used the appropriate notation to indicate radical atoms. However, the candidate did not use curved arrows to indicate the transfer of electrons.

Candidate's Response to Part (b) (iv)

(iv) Identify the type of reaction mechanism outlined in (b) (iii) **on page 5.**

Free Radical substitution.

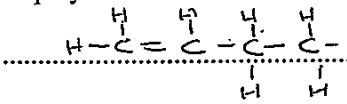
[1 mark]

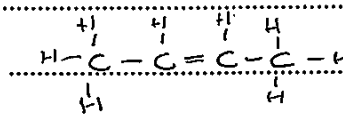
Examiner's Comments

The candidate accurately identified the type of reaction mechanism outlined in Part (b) (iii).

Candidate's Response to Part (c) (i)

(i) Write the displayed structural formula of TWO isomers of Q.

Isomer 1  but-1-ene.

Isomer 2  but-2-ene.

C-C-C=C

[2 marks]

Examiner's Comments

Candidates were generally able to identify the correct isomers. However, some candidates made errors in naming or drawing the structural formulae.

Candidate's Response to Part (c) (ii)

(ii) State whether Compound Q exhibits geometric (cis/trans) isomerism.

Yes.

[1 mark]

Examiner's Comments

Candidates were able to deduce that the molecule Q exhibited geometric isomerism.

Candidate's Response to Part (c) (iii)

(iii) State TWO reasons for your answer in (c) (ii).

The isomer but-2-ene exhibits geometric isomerism because similar groups are on the same side of the double bond (cis) and because similar groups are on different sides of the double bond on different carbon atoms (trans).

[2 marks]

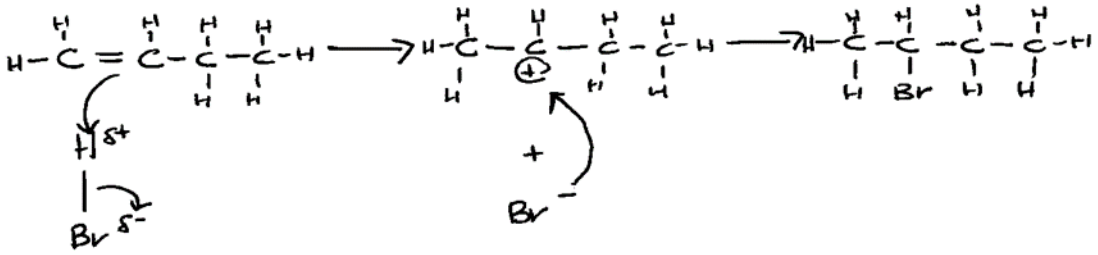
Examiner's Comments

The candidate stated two plausible reasons why Compound Q exhibits geometric (cis/trans) isomerism.

Most candidates did not obtain full marks because their explanations were either incorrect or lacked sufficient detail.

Candidate's Response to Part (c) (iv)

(iv) Outline the mechanism for the reaction between Compound Q and HBr, using curved arrows to show the movement of electrons.



[4 marks]

Examiner's Comments

The candidate represented the requested mechanism in a clear, logical and detailed manner. The candidate placed all charges on atoms/groups of atoms correctly and used arrows appropriately to show movement of electrons. The partial charges were also very well indicated by the candidate.

Candidate's Response to Part (c) (v)

(v) State the type of reaction mechanism outlined in (c) (iv).

Electrophilic Addition

[1 mark]

Examiner's Comments

Most candidates were able to identify the reaction mechanism outlined in Part (c) (iv).

Candidate's Response to Part (d) (i)

(i) Aqueous bromine is added to liquid pentane (in sunlight).

Brown to colourless

[2 marks]

Examiner's Comments
Many candidates described the expected colour changes correctly.

Candidate's Response to Part (d) (ii)

(ii) Aqueous bromine is added to liquid pentane (without sunlight).

Mixture remains brown, there is no colour change.

[1 mark]

Examiner's Comments
The accepted answer for the aqueous bromide ion is orange brown or red brown. However, most candidates stated 'brown' which was not an accepted answer.

Candidate's Response to Part (d) (iii)

(iii) Cold acidified potassium permanganate solution is added to liquid pentane.

Mixture remains purple, there is no colour change

[2 marks]

Examiner's Comments
The candidate's answer was accurate. The candidate indicated that there would be no difference in the initial colour and the final colour observed. However, some candidates lost marks because they did not indicate that even though the colour remained the same, a reaction took place. Therefore, answers such as 'no reaction' were incorrect.

Question 2

This question tested syllabus objectives 1.1, 2.1–2.6 and 3.4 from Module 2: Analytical Methods and Separation Techniques. The mean was 13.38 and the standard deviation 6.66.

Candidate's Response to Parts (a) (i) and (ii)

2. (a) Define EACH of the following terms.

(i) Accuracy

Accuracy refers to the degree of closeness of a measured value to the true value.

(ii) Precision

Precision refers to the closeness of a set of measured values to each other (reproducibility of the values).

[4 marks]

Examiner's Comments
The candidate defined the terms correctly.

Candidate's Response to Part (b) (i)

(i) List THREE reasons why $NaHCO_3$ can be used as a primary standard.

- It is stable towards air / does not react when exposed to air such as the oxygen in the air
- It has high purity
- It does not have water of crystallization in ~~sodium carbonate when~~ dried

[3 marks]

Examiner's Comments
The candidate earned full marks by providing three correct reasons why $NaHCO_3$ can be used as a primary standard.

Candidate's Response to Part (b) (ii)

(ii) State ONE reason why NaOH may NOT be used as a primary standard.

It is ~~due~~ not stable towards / absorbs oxygen in the air and forms a white precipitate leading to loss of NaOH molecules

[1 mark]

Examiner's Comments

The candidate stated one correct reason why NaOH may not be used as a primary standard.

Candidate's Response to Part (c) (i)

(i) Write the balanced equation for the reaction between sodium hydrogen carbonate and sulfuric acid.

$2NaHCO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$

[2 marks]

Examiner's Comments

In the exemplar, the candidate made an error when writing the first part of the equation for the reaction between sodium hydrogen carbonate and sulfuric acid. The correct formula is $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$.

Candidate's Response to Part (c) (ii)

(ii) Calculate the mass (in grams) of the sodium hydrogen carbonate that the student would use to neutralize the acid, if 23.50 cm^3 of the acid were used from the burette.

5 mol in 1000 cm^3
x in 23.50
$x = \frac{23.50 \times 5}{1000}$
$= 0.1175$ mol H_2SO_4 ✓

2 mol $NaHCO_3$ react with 1 mol H_2SO_4 ✓
x mol 0.1175 mol
$x = \frac{0.1175 \times 2}{1}$ ✓
$= 0.2350$ mol $NaHCO_3$

1 mol $NaHCO_3 = 23 + 1 + 12 + (3 \times 16)$
$= 84$ g/mol

84 grams in 1 mol
x 0.2350 mol
$x = \frac{0.2350 \times 84}{1}$ ✓
$= 19.74$ grams $NaHCO_3$ used

[4 marks]

Examiner's Comments
The candidate performed all calculations accurately and clearly and therefore earned a mark for each calculation.

Candidate's Response to Part (d) (i)

(i) Define the term 'mean volume'.

Mean volume is the average volume used for multiple titrations that were performed (total volume's ÷ number of trials) ✓

[1 mark]

Examiner's Comments
The candidate provided an adequate definition for the term *mean volume*.

Candidate's Response to Part (d) (ii)

(ii) Determine the mean volume from the titre values (to be used in the calculations).

25.25 + 25.35 + 25.3 = total volumes
= 75.90 cm³

Mean volume = 75.90 ÷ 3
= 25.30 cm³

[2 marks]

Examiner's Comments

The candidate calculated the mean volume correctly and provided the correct titre values. Therefore, the candidate was awarded full marks.

Candidate's Response to Part (d) (iii)

(iii) Define the term 'standard deviation'.

Standard deviation is the ~~value~~ amount that a value can deviate from the mean value to remain accurate and precise.

[1 mark]

Examiner's Comments

The candidate defined the term *standard deviation* correctly.

Candidate's Response to Part (d) (iv)

(iv) Using the following equation, justify the choice of the titre values selected in (d) (ii).

$$S = \frac{\sqrt{\Sigma(x-\bar{x})^2}}{n-1}$$

$\bar{x} = 25.30\,cm^3$

x	$x-\bar{x}$	$(x-\bar{x})^2$
25.25	-0.05	2.5×10^{-3}
25.35	0.05	2.5×10^{-3}
25.30	0	0

$\Sigma(x-\bar{x})^2 = (2.5\times10^{-3}) + (2.5\times10^{-3})$

$= 5.0\times10^{-3}$

$S = \sqrt{\frac{5.0\times10^{-3}}{3-1}}$

$= 0.05$

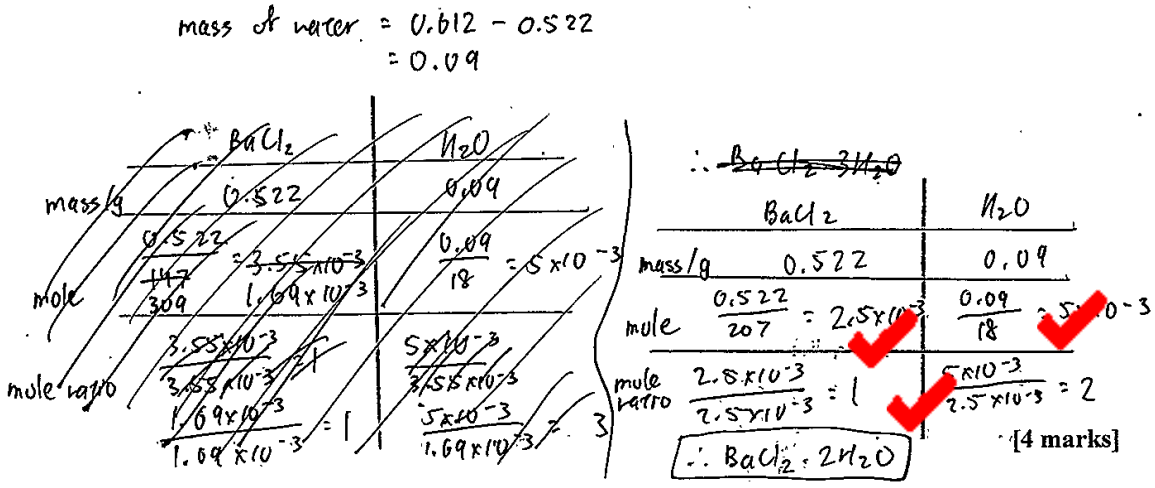
When only the 4th, 5th and 6th titre volumes used, the standard deviation of these values will be ± 0.05 cm³ which makes the results more precise and higher possibility of being accurate. The other titres exceed ± 0.05 cm³ of the mean which is 25.30 cm³. Meaning the range is 25.25 cm³ – 25.35 cm³. The Rough, 2nd and 3rd titre values fall out of that range, therefore these values are not [3 marks]

Examiner's Comments

The candidate provided a plausible justification for the choice of titre values.

Candidate's Response to Part (e)

(e) When 0.612 g of hydrated barium chloride is heated to constant mass, 0.522 g of residue is formed. Deduce the formula of hydrated barium chloride.



Examiner's Comments

The candidate provided accurate calculations and the correct formula but did not clearly identify what ratio was used. Hence, the candidate was awarded three out of four marks.

Candidate's Response to Part (f)

(f) To determine the ethanoic acid content of a particular brand of vinegar, a sample of the vinegar was titrated using sodium hydroxide solution.

Outline FIVE experimental steps that should be carried out to determine the ethanoic acid content of the vinegar.

1. Make a stock solution of the vinegar by measuring a volume of it (eg. 20cm³) and pour it into a volumetric flask (eg. 250cm³) and pour distilled water in it, shake then add water until the meniscus is on the ~~base~~ line.

2. Wash burette with distilled water then prime with NaOH of known concentration (eg. 2 mol/dm³) and fill up the ~~burette~~ burette until it is close to the 0 cm³ mark.

3. Pour some vinegar stock solution into a beaker. Wash pipette with distilled water, prime pipette with solution then wash and pipette a volume of the solution (eg. 25cm³) into a conical flask.

4. Add two drops of phenolphthalein in the conical flask.

5. Titrate the NaOH against the vinegar until the vinegar solution turn from colourless to a permanent faint pink colour. [5 marks]

Perform the whole procedure at least two more times to obtain three ~~the~~ values that differ no more than ± 0.10 cm³. Total 30 marks

Examiner's Comments

The candidate outlined five experimental steps that should be carried out to determine the ethanoic acid content of vinegar.

Question 3

This question tested syllabus objectives 1.1–1.2, 2.1–2.2, 4.1–4.3 and 5.1–5.4 from Module 3: Industry and The Environment. The mean was 10.51 and the standard deviation 4.53.

Candidate's Response to Part (a) (i)

(i) State ONE reason why a catalyst is needed in this reaction.

A catalyst is need to lower the activation energy of the reaction thus lowering the temperature needed and speed up the reaction.

[1 mark]

Examiner's Comments
The candidate was able to outline why a catalyst was needed in the reaction.

Candidate's Response to Part (a) (ii)

(ii) Using Le Chatelier's principle, explain the effect of temperature on the direction of equilibrium for the ammonia formation.

The reaction is exothermic (heat is released) in the forward direction. When temperature is increased, the point of equilibrium shifts to the left (favouring formation of N_2 and H_2). When temperature is decreased, the point of equilibrium shifts to the right (favouring formation of NH_3).

[2 marks]

Examiner's Comments
The candidate used *Le Chatelier's principle* to accurately explain the effect of temperature on the direction of equilibrium for the ammonia formation.

Candidate's Response to Part (a) (iii)

(iii) State whether the temperatures used in the Haber–Bosch synthesis favour the formation of high yields of ammonia.

The temperatures used are high and do not favour the formation of high yields of ammonia, only small amounts of ammonia will be produced.

[1 mark]

Examiner's Comments

The candidate correctly stated that the temperatures used in the Haber-Bosch synthesis do not favour the formation of high yields of ammonia.

Candidate's Response to Part (a) (iv)

(iv) Comment on the statement "High pressure conditions favour the formation of ammonia in high yields."

THIS STATEMENT IS TRUE HIGH PRESSURE WOULD DECREASE THE VOLUME THEREFORE SHIFTING THE EQUILIBRIUM TO THE RIGHT AND INCREASING THE YELD OF AMMONIA.

[2 marks]

Examiner's Comments

The candidate identified the correct shift in equilibrium but made no reference to the partial pressures of the products and the reactants.

Candidate's Response to Part (a) (v)

(v) With reference to Figure 1 **on page 13**, state TWO possible design limitations that could lead to reduced product yield.

i) ~~High~~ The reactor cannot withstand high pressures applied as it may not be strong enough. ii) There is ~~The catalyst~~ ii) The condens is not cool enough to liquefy the ammonia and ~~not enough energy supplied to the~~ ~~ii) The ammonia~~ remove it ~~is not rem removed as soon as it is formed due to~~ [2 marks] from ~~the absence of a cylinder to store it~~ the conden

Examiner's Comments

The candidate was able to provide two possible design limitations that could lead to reduced product yield.

Candidate's Response to Part (a) (vi)

(vi) Write the K_p expression for the Haber–Bosch process.

$K_p = \frac{2[NH_3]}{[N_2][H_2]}$ [1 mark]

Examiner's Comments

Even though the candidate provided a satisfactory expression, the correct K_p expression for the Haber-Bosch process is $K_p = P_{NH3}^2/P_{H2} \times P_{H2}^3$.

Candidate's Response to Part (a) (vii)

(vii) State the impact of the catalyst on the K_p of the reaction.

The catalyst does not affect the K_p of the reaction. [1 mark]

Examiner's Comments

The candidate failed to state the impact of the catalyst on the K_p of the reaction. It must be noted that catalysts do not affect the equilibrium constant but they affect the reaction of the forward and reverse reactions of the equilibrium.

Candidate's Response to Part (b) (i)

(i) a higher yielding process because ..The catalyst will speed up the reaction and more N_2 and H_2 will be used up in one cycle and no need to feed back unused gases therefore also more time efficient. Lower temperature favours forward reaction (formation of ammonia).....

[1 mark]

Examiner's Comments
The candidate identified that lower temperatures increase the formation of ammonia.

Candidate's Response to Part (b) (ii)

(ii) a more energy efficient process because ..No high temperature or high pressure required which can take a lot of energy to maintain those conditions.....

[1 mark]

Examiner's Comments
The candidate correctly stated that neither high temperature nor high pressure is required for a more energy efficient process.

Candidate's Response to Part (b) (iii)

(iii) a lower cost process because ..IT OPERATES UNDER LOW PRESSURE WHICH THEREFORE MEANS SAVES MONEY, AS COMPRESSORS ARE EXPENSIVE TO MAINTAIN. ALSO.....

[2 marks]

Examiner's Comments
The candidate provided a partially correct response.

Candidate's Response to Part (b) (iv)

(iv) a significant discovery because ...USES UV LIGHT WHICH IS A NATURAL RESOURCE IT NOT ONLY SAVES MONEY, IS MORE EFFICIENT AND YIELDS MORE AMMONIA THAN HABER-BOSH. LESS STRESS ON NATURAL GAS RESOURCES AS IT IS MORE ENERGY EFFICIENT, PRODUCES LESS WASTE

[2 marks]

Examiner's Comments

The candidate provided an incorrect response. Candidates are urged to note that in comparison with the Haber-Bosch method, the method shown in Part (b) can prove to be a significant discovery because the reaction is being conducted under catalytic conditions that are easy to maintain and operate with high yields.

Candidate's Response to Part (b) (v)

(v) Comment on the statement "The production of ammonia under standard atmospheric conditions would prove to be more efficient in the presence of a catalyst than the Haber–Bosch process."

The reaction will take place at a lower temperature which will favour the production of the ammonia and the catalyst also speed up the reaction and further decrease the temperature needed. The Haber-Bosch process requires high temperature and ~~while~~ pressure but the yield is low.

[2 marks]

Examiner's Comments

The candidate used two key points to outline why the production of ammonia would be more efficient in the presence of a catalyst. The two key points were

- the reaction would take place at a lower temperature which would make the production of ammonia favourable
- the inclusion of the catalyst would increase the speed of the reaction.

Candidate's Response to Part (b) (vi)

(vi) Identify another feature in the design that makes it 'green', apart from the use of a catalyst in the existing Haber–Bosch process.

THE RECYCLING OF UNUSED N_2 AND H_2 GASES MAKES IT 'GREEN'

AS THESE GASES ARE NOT RELEASED INTO THE ATMOSPHERE TO CAUSE POLLUTION. [1 mark]

Examiner's Comments

The candidate correctly stated that recycling H_2 and N_2 makes the Haber-Bosch process "green".

Candidate's Response to Part (c) (i)

(i) In the yeast-catalysed production of ethanol, 60% of the world's ethanol is obtained from the fermentation of sucrose. Write ONE equation that represents a step in this process.

$C_6H_{12}O_{6(aq)} \xrightarrow[\text{ENT. NO OXY}]{\text{ZYMASE}} 2\ C_2H_5OH_{(aq)} + 2\ CO_{2(g)}$

[2 marks]

Examiner's Comments

The candidate wrote an incorrect equation. Candidates should have provided one of the following equations.

- $C_{12}H_{22}O_{11}$ (Sucrose) + H_2O → $C_6H_{12}O_6$ (Glucose) + $C_6H_{12}O_6$ (Fructose)
- $C_6H_{12}O_6$ (Glucose/Fructose) → 2 CH_3CH_2OH (Ethanol) + CO_2

Candidate's Response to Part (c) (ii)

(ii) Bioethanol is the name given to ethanol produced from biomass or plant material. Write TWO statements that support the idea that ethanol is a green resource.

Statement 1

Biomass or plant material used to create ethanol are renewable resources while ethene that have to be obtained from crude oil which is a non renewable resource.

[1 mark]

Statement 2

The use of ethanol as a fuel will result in a cleaner combustion reaction compared to gasoline which will create more carbon monoxide which is bad for people's health.

[1 mark]

Examiner's Comments

The candidate provided an incorrect answer for Statement 1. However, the answer given by the candidate for Statement 2 was correct. Another answer which could have been given by candidates was *plant feedstocks that are grown to generate ethanol reduce greenhouse gas emissions by absorbing CO_2 from the atmosphere.*

Candidate's Response to Part (c) (iii)

(iii) Sugar cane requires four times more water during ethanol production when compared to sugar beets. State TWO factors that would preclude countries in the Caribbean from considering sugar beets as a viable source crop for ethanol production.

- Water as a raw material : the availability of and proximity to the raw materials needed.
- Historical factors : the caribbean has a history of sugar production and [speaks to culture] place a similar factory in that location.

[2 marks]

Examiner's Comments

The candidate's answer is partially correct. In order to improve the answer, the candidate should have included information related to the fact that the climate of the Caribbean can be considered unsuitable for growing sugar beets since this crop grows better in cooler climates.

Candidate's Response to Part (c) (iv)

(iv) Ethanol is used in mouthwash formulations in addition to active ingredients such as menthol, thymol and eucalyptol. The purpose of these ingredients is to aid in the breakdown of plaque on teeth. Describe the role of ethanol in this process.

ETHANOL IS AN ANTISEPTIC AND SO IS USED TO KILL BACTERIA. ETHANOL CAN ALSO BE USED AS A SOLVENT FOR THESE OTHER INGREDIENTS.

[2 marks]

Examiner's Comments

The candidate correctly stated that ethanol can be used as a solvent.

Candidate's Response to Part (c) (v)

(v) In a brief experiment, a student sought to make mouthwash by trying a series of formulations. Three of the formulations are listed below. Match EACH formulation using the letters A, B or C with the appropriate set of characteristics that best describes it.

- Formulation A: Deionized water (10%), ethanol (40%), menthol (0.092%), thymol (0.042%), eucalyptol (0.066%)
- Formulation B: Deionized water (40%), ethanol (10%), menthol (0.092%), thymol (0.042%), eucalyptol (0.066%)
- Formulation C: Deionized water (80%), ethanol (5%), menthol (0.092%), thymol (0.042%), eucalyptol (0.066%)

Characteristics	Formulation
Characteristics I: High boiling point, low cooling effect, high viscosity, moderate antimicrobial activity against oral bacteria	C
Characteristics II: Low boiling point, strong cooling effect, low viscosity, strong antimicrobial activity against oral bacteria	A
Characteristics III: Intermediate boiling point, moderate cooling effect, medium viscosity, intermediate anti-microbial activity against oral bacteria	B

[3 marks]

Examiner's Comments

The candidate matched each formulation to the appropriate set of characteristics that best described it.

PAPER 032 – ALTERNATIVE TO THE SCHOOL BASED ASSESSMENT

Paper 032, Alternative to School-Based Assessment, was taken by private candidates. The paper comprised three questions which were based on syllabus objectives 2.6 and 2.9 from Module 1: The Chemistry of Carbon Compounds, 2.4–2.5 from Module 2: Analytical Methods and Separation Techniques, and 3.3 from Module 3: Industry and the Environment.

Overall, the performance of candidates was weak. The paper was worth a total of 45 marks. The mean score was 13.90 and the standard deviation 5.66.

Question 1

This question involved the testing of organic compounds to differentiate between unknown liquids and to categorize these liquids aldehydes, alcohols or ketones.

Candidate's Response to Part (a)

TABLE 1: TESTS ON COMPOUNDS Q, R AND S

	Test	Observation		
		Compound Q	Compound R	Compound S
1a.7 1b.1 1c.1 2a.2 2b.1 2c.6 2d.2 3a.0 3b.0 3c.2 3d.3 3e.2 3f.0 3g.1	Carry out the following tests on approximately 2 cm^3 of EACH compound.			
	Add $K_2Cr_2O_7$ (aq) followed by a few drops of dilute H_2SO_4 and warm gently.	(i) ~~No colour~~ Colour change to green ~~Precipitate is soluble~~ ✓	(ii) Colour change from orange to green ✓	(iii) no ~~or~~ colour change observed ✓
	Add approximately 2 cm^3 of NaOH (aq) followed by I_2 dropwise until I_2 is no longer decolourized. Warm gently.	(iv) No observable change. Solution slightly cloudy. ✓	(v) Yellow precipitate ✓ formed on heating. Solution was light yellow before heating	(vi) Cloudy when reagents are added. ✓ No further change on heating
	Add a few drops of 2,4-DNPH.	(vii) ~~No~~ Orange precipitate formed. ✓	(viii) no precipitate formed ✗	(ix) orange precipitate formed. ✓
	To approximately 2 cm^3 of $AgNO_3$ (aq), add a few drops of NaOH (aq) followed by NH_3 (aq) until the precipitate dissolves. Add the compound and warm the mixture.	(x) Brown precipitate formed. Sparingly soluble in NH_3 ✓	(xi) Black ✗ precipitate formed on addition of NaOH. Ppt is insoluble	(xii) Brown precipitate formed. ✗ Sparingly soluble in $NH_{3(aq)}$.

[9 marks]

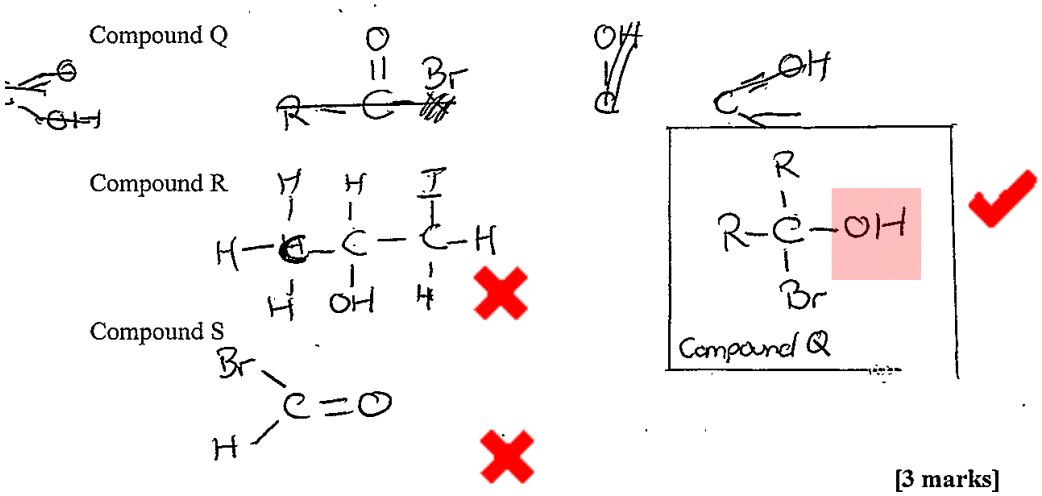
Examiner's Comments

In the exemplar, the candidate demonstrated good data reporting skills.

Generally, candidates seemed to be unclear about what data should have been recorded on the data sheet and often reported excessively or inadequately.

Candidate's Response to Part (b)

(b) Based on your recorded observations in Table 1, write the structural formulae of the functional groups present in Compounds Q, R and S.



[3 marks]

Examiner's Comments

Candidates were required to identify the presence of three functional groups, using inferences made from qualitative data gathered. Fewer than five candidates were able to write structural formulae for at least two functional groups correctly.

Candidate's Response to Part (c)

(c) State ONE reason which formed the basis for EACH of the answers given in (b).

Compound Q

It turned light yellow in the last test, indicating it's saturated. ✗

Compound R

It turned light green in the last test, indicating it's ~~unsaturated~~ unsaturated. ✗

Compound S

It turned orange when during the first test, indicating it's an acid. ✗

[3 marks]

Examiner's Comments

Part (c) was not well answered by most candidates.

Question 2

Candidates were assessed on their ability to

- provide experimental information related to titrimetric analysis
- record the data appropriately from the titrimetric analysis
- perform calculations based on data obtained from the titrimetric analysis

Candidate's Response — Parts (a) to (d)

2. A student is given the task of determining the concentration of ethane-1, 2-dioic acid, $H_2C_2O_4$, by titrating 25 cm^3 portions of the acid with a standard solution of potassium manganate (VII), $KMnO_4$, containing 0.02 mol dm^{-3}. Figure 1 shows the readings on the burette before and after each titration.

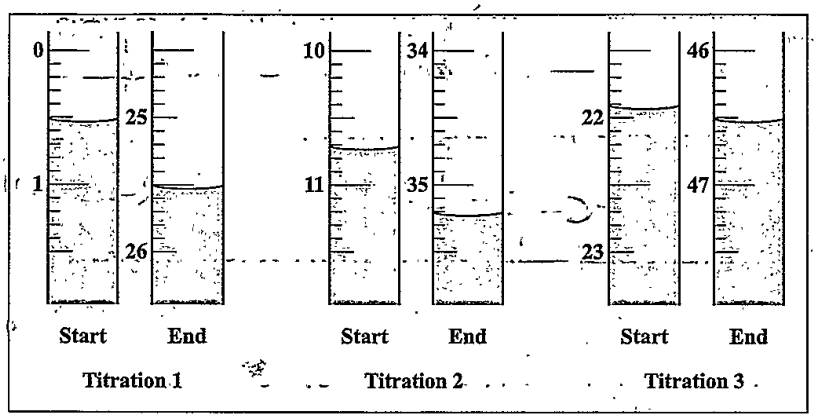


Figure 1. Burette reading

(a) (i) State which substance in the titration is performing the role of the indicator.

Potassium manganate (VII)

[1 mark]

(ii) Identify the colour change which would be expected at the end of the reaction.

Colourless to light pink.

[1 mark]

(b) In taking readings of liquids, the bottom of the meniscus is usually read. However, in the case of $KMnO_4$ (aq), this procedure is not followed. State the reason for this deviation from the normal procedure.

This is due to the colour of the $KMnO_4$(aq).
It makes it difficult to clearly see the meniscus.

[1 mark]

(c) (i) In the space below, construct a table to record the titration results. Include the initial and final burette readings, and the volume of $KMnO_4$ (aq) used.

	TITRATION 1 $/cm^3$	TITRATION 2 $/cm^3$	TITRATION 3 $/cm^3$
FINAL VOLUME $KMnO_4$ cm^3	25.52	35.22	46.53
INITIAL VOLUME $KMnO_4$ cm^3	0.53	10.72	21.94
VOLUME USED cm^3	24.99	24.50	24.59

TABLE SHOWING VOLUME OF $KMnO_{4(aq)}$ USED IN STANDARDIZING ETHANE-1,2-dioic ACID

[5 marks]

(ii) State the volume of $KMnO_4$ (aq) to be used in the calculation.

Avg of Vol of $KMnO_{4(aq)}$ $= \frac{24.99 + 24.50 + 24.59}{3}$

$= 24.7 cm^3$

[1 mark]

(iii) Given the ionic equation for the reaction occurring in the titration,

$5C_2O_4^{2-}(aq) + 2MnO_4^-(aq) + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2(g) + 8H_2O(l)$

calculate the concentration of the ethane-1, 2-dioic acid, in mol dm^{-3}.

~~Conc of $KMnO_4$ =~~

Moles of $KMnO_4 = 0.02 \times \frac{24.7}{1000}$

$= 0.000494$

Ratio $5C_2O_4^{2-} : 2MnO_4^-$

$\therefore$ Moles of $C_2O_4^{2-} = \frac{0.000494}{2} \times 5$

$= 0.001235$ moles

Mole Ratio = 5:2

$0.001235 \rightarrow 250 cm^3$

$\therefore 1 cm^3 \rightarrow \frac{0.001235}{250}$

$1000 cm^3 \rightarrow \frac{0.001235}{250} \times \frac{1000}{1}$

$\rightarrow 0.00494$ moles

Conc of $H_2C_2O_4$

$= 0.00494$ mol dm^{-3}

[3 marks]

(d) Briefly outline the steps to be taken in performing the titration.

- $H_2C_2O_4$ is prepared by dissolving a known volume in a 250 cm^3 volumetric flask, filling with distilled water to the mark.
- 25 cm^3 of the diluted solution is pipetted into a conical flask
- The burette is filled with ~~pota~~ potassium manganate (0.2 mol dm^{-3}).
- Begin titration, swirling conical flask, until first permanent pink colour appears.
- Repeat steps until vol of $KMnO_4(aq)$ is constant. **[3 marks]**

Total 15 marks

Examiner's Comments

In Part (a) to Part (d), the candidate demonstrated good skills in analysis and data presentation. The candidate was able to identify the substance in the titration which performed the role of the indicator and the expected colour change. The candidate was also able to state why the meniscus could not be read in this titration. Additionally, the candidate constructed the required table to record the titration results, including the initial and final burette readings and the volume of $KMnO_4$ (aq) used. The candidate also performed the correct calculations to determine the ethane-1, 2-dioic, in mol dm^{-3} and outlined the steps to be taken to perform the titration.

Question 3

This question focused on the planning and design of an experiment to determine the oil dispersant action of a given cactus plant against a viscous oil.

Candidate's Response to Part (a)

3. Oil dispersants are compounds used in the crude oil industry to aid in the clean–up of oil spills. Mucilaginous plants such as the Cactus are known to have properties similar to oil dispersants, which are comparable to commercial detergents.

Plan and design an experiment that measures the oil dispersant action of the Cactus plant against a viscous oil, to examine its potential as a 'green' oil dispersant as compared to a standard commercial detergent. Your answer should include the following:

(a) Hypothesis

The cactus plant will be able to act as a 'green' oil dispersant and will be able to be used in oil spill clean-up.

[1 mark]

Examiner's Comments

In Part (a), candidates were required to derive an appropriate hypothesis. Many candidates had difficulty providing an appropriate hypothesis. In the exemplar, the candidate provided a suitable answer.

Candidate's Response to Part (b)

(b) Aim

To ~~determine~~ measure the oil dispersant action of a cactus against a viscous oil.

[1 mark]

Examiner's Comments

Generally, candidates were able to identify the aim of the experiment. In the exemplar, the candidate did so effectively.

Candidate's Response to Part (c)

(c) Apparatus and materials

- 2 250 ml beakers - stirring rods
- Cactus plant extract (10 ml) - Distilled water
- ~~50~~ 10 ml Standard detergent
- 50 ml of oil

[3 marks]

Examiner's Comments

Many candidates were able to derive an appropriate list of apparatus and materials. In the exemplar, the candidate created an exhaustive list.

Candidate's Response to Part (d)

(d) Procedure

- Place 50ml of distilled water in 2 beakers. Label them A and B.
- Add 10ml of oil to both beakers and stir.
- Add 10ml of standard detergent to beaker A and stir.
- Record observations over a five minute period.
- Add 10ml of cactus extract to beaker B and stir.
- Record observations over a five minute period.

[4 marks]

Examiner's Comments

The candidate provided the steps that were suitable for conducting the experiment. Generally, candidates experienced difficulty answering Part (d) and, in many instances, did not provide an answer.

Candidate's Response to Part (e)

(e) Variables

- Manipulated

Oil dispersant used. Cactus extract and standard commercial detergent.

[1 mark]

- Responding

The: How the oil responds to the dispersant.

[1 mark]

- Controlled

Volume of water, volume of dispersant, volume of oil, time observed.

[1 mark]

Examiner's Comments

Part (e) was not well answered by most candidates. However, in the exemplar, the candidate was able to provide an appropriate answer.

Candidate's Response to Part (f)

(f) Expected results

The viscous oil would be more in the beaker as the end product. Thus the properties would not be the same as with the cactus.

Examiner's Comments

Determining the expected results that would govern a successful experiment proved to be challenging for most candidates. In the exemplar, the candidate did a fair job in stating the expected results.

Candidate's Response to Part (g)

(g) ONE precaution to be taken

Ensure that the end result is read at eye level to get accurate results

[1 mark]

Examiner's Comments

Generally, applicable precautions were identified by candidates.