CARIBBEAN EXAMINATIONS COUNCIL

CSEC® CHEMISTRY

Subject Report with Exemplars

May/June 2023

CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION

MAY/JUNE 2023

CHEMISTRY
GENERAL PROFICIENCY

Table of Contents

INTRODUCTION

This guide has been compiled using candidates' responses to the 2023 May/June CSEC Chemistry examination.

The examination consisted of the following papers.

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

In 2023, 65.75 per cent of candidates earned acceptable grades (Grades I–III), compared with 59.70 per cent of candidates in 2022. The percentage of candidates gaining Grade I was 15.41 per cent, compared with 15.71 per cent of candidates in 2022.

PAPER 01 — MULTIPLE CHOICE

This paper consisted of 60 compulsory multiple-choice items. Each item was worth one mark each. Fifty items tested candidates' knowledge and comprehension of the syllabus content while 10 items tested candidates' use of knowledge.

In 2023, the mean score was 37.07 out of 60 (61.78 per cent) and the standard deviation 12.98.

PAPER 02 — STRUCTURED/EXTENDED ESSAY

Paper 02 was a structured/extended essay paper. The paper consisted of one compulsory data analysis question, two structured questions and three extended response questions.

In 2023, the mean score was 36.87 of 100 (36.87 per cent) and the standard deviation 18.64.

Question 1

This question tested syllabus objectives from Section A: Principles of Chemistry — 6.2, 6.5, 10.1, 10.2, 10.3 and 10. 4.

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

(a) (i) Define the term 'rate of reaction'.

Rate of reaction is the measured change in the ~~conc~~ concentration of reactant with time.

(1 mark)

Examiner's Comments

This candidate was able to correctly define the term *rate of reaction*.

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

(ii) Define the term 'catalyst'.

Catalyst is an enzyme that speed up reactions without ~~them~~ being used up in the reaction.

(2 marks)

Examiner's Comments

This candidate was able to correctly define the term *catalyst*.

Candidate's Response to Part (b)

(b) For EACH experiment shown on the stop clocks in Figure 1 **on page 4**, record, in Table 1, the time taken for the hydrogen peroxide (H_2O_2) to decompose.

TABLE 1: THE EFFECT OF THE CONCENTRATION OF HYDROGEN PEROXIDE ON THE RATE OF REACTION

Experiment	Concentration of Hydrogen Peroxide H_2O_2 (mol/dm^3)	Time (s)	Rate of Reaction (1/Time) (s^{-1})
1	0.10	59s	0.017
2	0.15	42s	0.024
3	0.20	31s	0.032
4	0.25	25s	0.040
5	0.30	21s	0.048

(5 marks)

Examiner's Comments

The candidate was able to correctly read and record the times displayed on the stop clocks provided in Figure 1.

Candidate's Response to Part (c)

TABLE 1: THE EFFECT OF THE CONCENTRATION OF HYDROGEN PEROXIDE ON THE RATE OF REACTION

Experiment	Concentration of Hydrogen Peroxide H_2O_2 (mol/dm³)	Time (s)	Rate of Reaction (1/Time) (s^{-1})
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5	0.30	21s	0.048

(5 marks)

(c) Complete Table 1 by calculating the rate of reaction ($\frac{1}{\text{Time}}$), **to three decimal places,** for EACH of the experiments. **(5 marks)**

Examiner's Comments

The candidate correctly calculated the rate as 1/t, rounded to three decimal places.

Candidate's Response to Part (d)

(d) Using the axes provided in Figure 2 **on page 7**, plot a graph of rate of reaction versus concentration of hydrogen peroxide (H_2O_2), from the information in Table 1. Draw the line of best fit through the points. **(5 marks)**

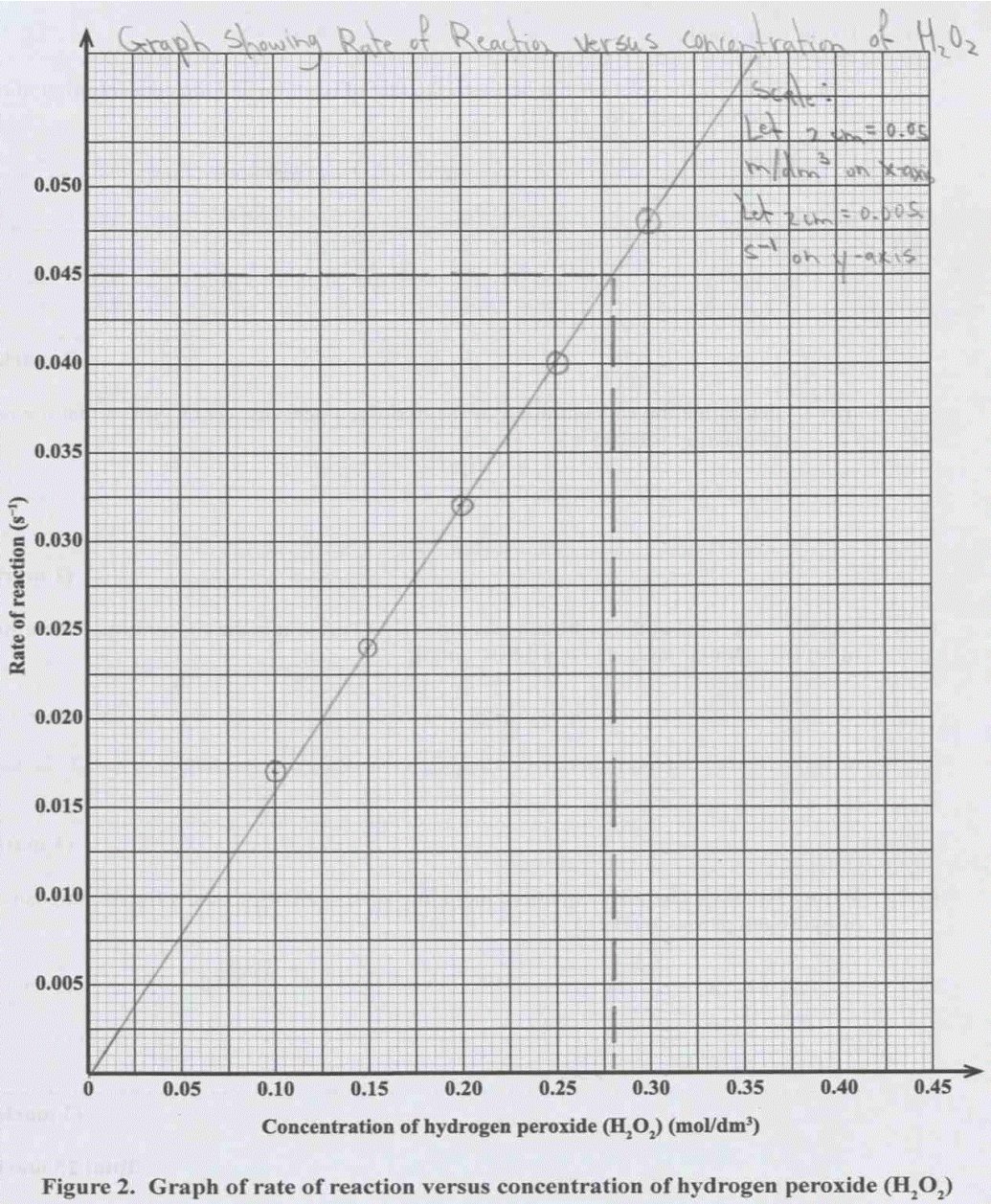


Figure 2. Graph of rate of reaction versus concentration of hydrogen peroxide (H_2O_2)

Examiner's Comments

The candidate correctly applied the Factor Theorem to demonstrate that $x-3$ is a factor of the given function.

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

(e) Using your graph,

(i) describe the relationship between the rate of reaction and the concentration of the hydrogen peroxide (H_2O_2)

The relationship is directly proportional since as concentration of the hydrogen peroxide (H_2O_2) increased, rate of reaction also increased.

(2 marks)

Examiner's Comments

The candidate was able to correctly describe the relationship between the rate of reaction and the concentration of hydrogen peroxide as shown in the graph drawn.

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

(ii) determine the concentration of the hydrogen peroxide (H_2O_2) given that the rate of reaction is 0.045 s^{-1}.

0.23 mol/dm^3

(1 mark)

Examiner's Comments

The candidate was able to correctly interpolate the concentration of hydrogen peroxide, given that the rate of reaction was 0.045 s^{-1}.

Candidate's Response to Part (f)

(f) Calculate the mass of the hydrogen peroxide (H_2O_2) present in the concentration identified in (e) (ii). [Molar mass, H_2O_2 = 34.01 g/mol]

of H_2O_2 = 34.01 g/mol

mass of 0.28 mol.dm^3 H_2O_2 = 34.01 x 0.28 = 9.523 g.dm^3

(1 mark)

Examiner's Comments

The candidate was able to use the molar mass to correctly calculate the mass of hydrogen peroxide present at a concentration corresponding to a reaction rate of 0.045 s^{-1}.

Candidate's Response to Part (g)

(g) Write a balanced chemical equation, including state symbols, to show the decomposition of hydrogen peroxide (H_2O_2).

$2H_2O_2(l)$ $\xrightarrow{KI\ catalyst}$ $O_2(g) + 2H_2O(l)$

(3 marks)

Examiner's Comments

The candidate was able to write a correct balanced chemical equation showing the products formed from the decomposition of hydrogen peroxide.

Question 2

This question tested syllabus objectives from Section A: Principles of Chemistry — 1.2, 1.3. 5.5 and 6.5.

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

(a) At atmospheric pressure, water exists in three states of matter while carbon dioxide exists in only two states.

(i) List the THREE states of matter in which water can exist.

Solid , Liquid and gas.

Examiner's Comments

The candidate was able to correctly identify the three states of matter in which water can exist.

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

(ii) Describe the energy of the particles in EACH of the three states listed in (a) (i).

In Solids, there are strong intermolecular forces of attraction between particles, thus there ~~is~~ are low kinetic energy (particulate energy) of particles. In Liquids there are weaker forces of attraction as compared to ~~gases~~ solids but stronger forces of attraction as compared to gases, thus the the particulate energy (Kinetic) of the particles are more than in ~~liquids~~ solids but less than in gases. In gases there are very weak inter-molecular forces, thus there is very high particulate energy as particles move about freely.

Examiner's Comments

The candidate was able to correctly describe the energy of particles in solids, liquids and gases.

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

(iii) Name the process which occurs when carbon dioxide changes from one state to another.

Sublimation.

Examiner's Comments

The candidate was able to correctly describe the process that occurs when carbon dioxide changes state.

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

(iv) Describe how the arrangement of the carbon dioxide particles changes as carbon dioxide undergoes the process named in (a) (iii).

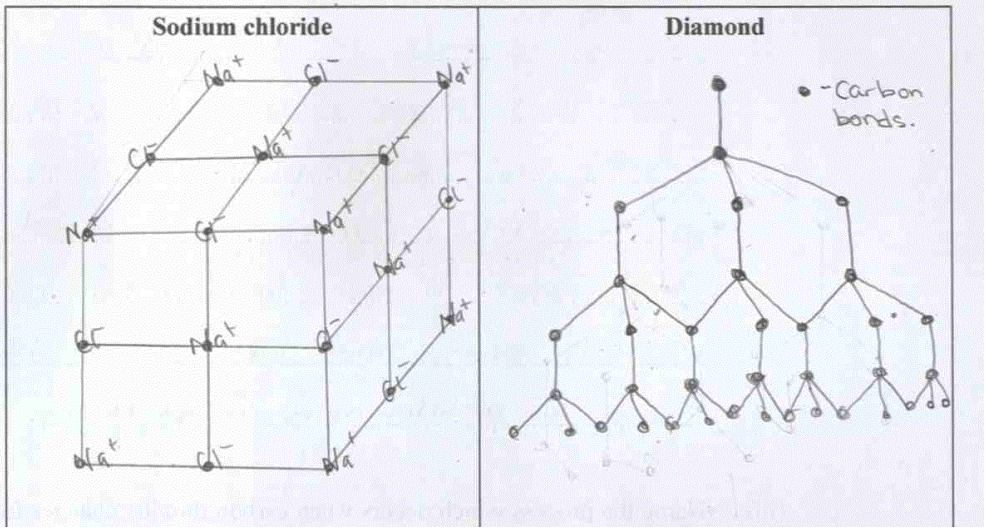
During sublimation, CO_2 goes from solid state directly to gaseous state. When CO_2 is in solid state, the particles are in a lattice, tightly packed with little spaces between particles. As CO_2 particles sublime, the particles gain a lot of space in between them, they loose the lattice structure, moving about freely. ~~and fill~~ **(2 marks)**

Examiner's Comments

The candidate was able to correctly describe how the arrangement of the carbon dioxide particles changed when carbon dioxide underwent the process of sublimation.

Candidate's Response to Part (b)

(b) Using appropriate diagrams, illustrate the lattice structure of sodium chloride crystal and the giant molecular structure of diamond.



Examiner's Comments

The candidate was able to correctly draw the lattice structure of sodium chloride and the giant molecular structure of diamond.

Candidate's Response to Part (c)

(c) In solution, two metals, A and B, form A^+ and B^{2+} ions respectively. Metal A displaces Fe from a solution containing Fe^{2+} ions but Metal B does not.

Write a balanced ionic equation to show the reaction between Metal A and Fe^{2+} ions.

$2A(s) + Fe^{2+}(aq) \longrightarrow 2A^{+}(aq) + Fe(s)$

(2 marks)

Total 15 marks

$\times 2: 2A^{0}(s) \longrightarrow 2A^{+} + 2e^{-}$

$Fe^{2+} + 2e^{-} \Rightarrow Fe^{0}$

$2A(s) + Fe^{2+}(aq) \longrightarrow 2A^{+}(aq) + Fe(s)$

Examiner's Comments

The candidate was able to correctly write a balanced equation for the reaction between Metal A and Fe^{2+} ions, using the information provided.

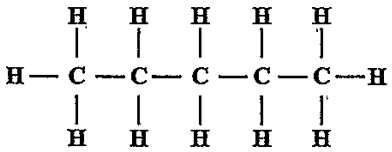
Question 3

This question tested syllabus objectives from Section B: Organic Chemistry — 2.2, 2.5, 3.6 and 3.7.

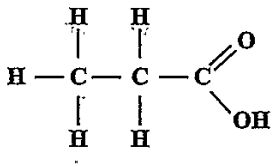
Candidate's Response to Part (a)

3. Figure 3 shows the fully displayed structures of three compounds, A, B and C, which are from different homologous series.

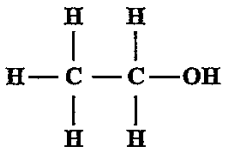
$CH_3CH_2COOCH_2CH_3 + H_2O_{(l)}$



Compound A



Compound B



Compound C

Figure 3. Fully displayed structures of Compound A, Compound B and Compound C

(a) State the homologous series to which Compounds A and B belong.

Compound A ALKANE ALKANE

Compound B ALKANOIC ACIDS

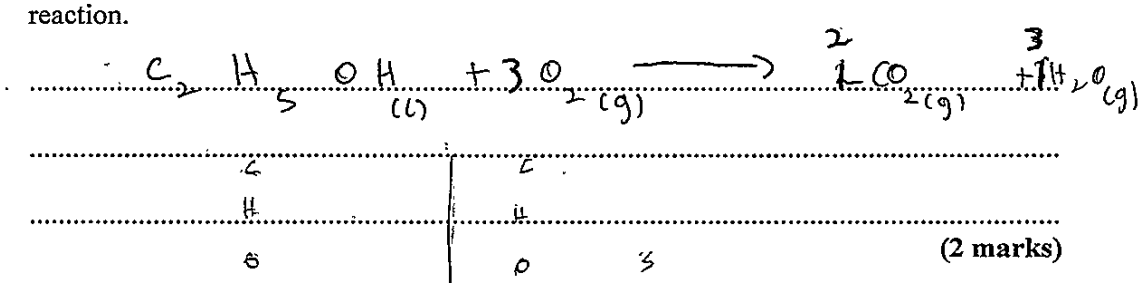
(2 marks)

Examiner's Comments

The candidate was able to correctly state the homologous series of compound A and B, given their fully displayed structures.

Candidate's Response to Part (b)

(b) Compound C burns with a blue flame in oxygen. Write a balanced equation for this reaction.



(2 marks)

Examiner's Comments

This candidate was able to write a balanced equation for the reaction when Compound C (ethanol) is burnt in oxygen.

Candidate's Response to Part (c)

(c) State which of the two compounds, A or C, is more soluble in water. Give a reason for your answer.

More soluble compound C

Reason C has an -OH (Hydroxyl) group which allows for it to dissolve in polar $H_2O_{(l)}$

(2 marks)

Examiner's Comments

The candidate was able to correctly identify that alcohol (Compound C) is more soluble than alkane (Compound A) due to the presence of a polar hydroxyl group.

Candidate's Response to Part (d) — Sample 1

(d) State whether Compound B or Compound C would react more vigorously with sodium metal and give a reason for your choice.

More reactive compound: B

Reason: Due to it being an acid and contains a [C(=O)-O-H] functional group making it an acid.

(2 marks)

Candidate's Response to Part (d) — Sample 2

(d) State whether Compound B or Compound C would react more vigorously with sodium metal and give a reason for your choice.

More reactive compound: B (alkanoic acid)

Reason: sodium metal is a reactive metal and these type of metals react vigorously with acids. Compound B is more acidic than C

(2 marks)

Examiner's Comments

The candidate was able to correctly identify that propanoic acid (Compound B) is more reactive than ethanol (Compound C) due to its greater acidity or the presence of the carboxylic acid (COOH) group.

Candidate's Response to Part (e)

(e) Write a balanced equation for the reaction of Compound C with sodium metal.

$2\ C_2H_5OH_{(l)} + 2Na_{(s)} \rightarrow 2C_2H_5O^-Na^+_{(aq)} + H_{2(g)}$

Ethanol ..... Sodium metal ..... Sodium ethanoate ..... Hydrogen gas

(2 marks)

Examiner's Comments

The candidate was able to write a balanced chemical equation for the reaction between ethanol (Compound C) and sodium metal.

Candidate's Response to Part (f)

(f) Describe ONE test that could be used to identify the gas that is produced in the reaction of Compound C with sodium metal.

Place a ~~glowing~~ lighted splint into the test tube with test chemicals, if the gas ($H_{2(g)}$) is present it will produce a squeaky pop sound.

(2 marks)

Examiner's Comments

The candidate was able to correctly describe the test and expected observations for hydrogen gas produced from the reaction between metals and acids.

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

(g) Compound B and Compound C react together in the presence of a catalyst to form Compound D.

(i) State the name of the catalyst.

Conc H_2SO_4

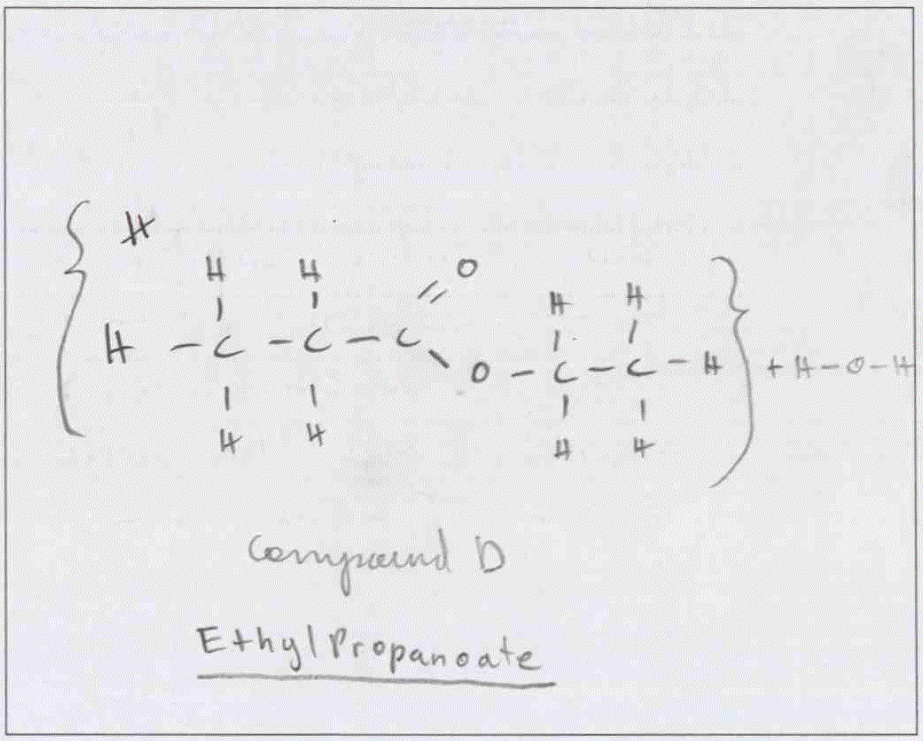
(1 mark)

Examiner's Comments

The candidate was able to correctly identify concentrated sulfuric acid as the catalyst required for the reaction between an acid and an alcohol.

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

(ii) Draw the FULLY displayed structure of Compound D.



(2 marks)

Examiner's Comments

The candidate was able to draw the fully displayed structure of the ester formed from the reaction between propanoic acid and ethanol correctly.

Question 4

This question tested syllabus objectives from Section A: Principles of Chemistry — 5.6, 9.1 and 9.2.

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

4. (a) Sulfur and magnesium are two elements in the same period of the periodic table. The different properties of the oxides of these elements are presented in Table 2.

TABLE 2: PROPERTIES OF OXIDES

	Oxide of Sulfur	Oxide of Magnesium
State	Gas	Solid
Melting Point (°C)	-72	2852

(i) With reference to bonding, explain the difference in melting point between the oxides of sulfur and magnesium.

The bonding that occurs in magnesium oxides ~~is~~ are ionic bonding which involves the cations from a metal and anions from a non-metal ~~bonding to form~~ forming strong bonds due to strong electrostatic forces of attraction. These strong bonds and stability leads to very high melting points. ~~Sulpho~~ Sulphur oxides use covalent bonding which involves ~~share~~ a sharing a pair of electrons to form strong bonds in atoms but weak Vanderwaal's forces in molecules due to no strong electrostatic force. These weak bonds lead to a low melting point.

Examiner's Comments

The candidate was able to refer correctly to the presence of ionic bonding within oxides of magnesium and the strong electrostatic attraction/bonding between ions (cations and anions) that contribute to their high melting points. Additionally, the candidate was able to refer to the presence of covalent bonding within oxides of sulfur and specifically to the weak intermolecular forces between molecules of oxides of sulfur, which account for their low melting points.

Candidate's Response to Part (a) (ii) — Sample 1

(ii) Explain whether the oxides of sulfur and magnesium will conduct electricity and, if so, under what conditions.

The oxides of magnesium will conduct electricity if molten or in an aqueous solution because under these conditions, its ions can freely move through the substance. Oxides of sulfur will not conduct electricity since there are no free charges as all the valence electrons are being shared between atoms.

Examiner's Comments

The candidate was able to correctly explain that the oxides of magnesium are able to conduct electricity when in the molten state due to the presence of mobile ions that can carry the electric charge. Additionally, the candidate was able to correctly explain that the oxides of sulfur will not conduct electricity due to the absence of free electrons to conduct the electric charge.

Candidate's Response to Part (a) (ii) — Sample 2

Question No. 4ai

$MgO \rightarrow H$ $SO_3^{2-} + H^+ \rightarrow H_2SO_3$

4aii) The oxides of sulfur would be able to conduct electricity in aqueous solution. As this makes the water aweher allowing it to carry a charge. $SO_{3(aq)}^{2-} + H_{(aq)}^{+} \rightarrow H_2SO_{4(aq)}$. Whereas magnesium oxide would ~~be~~ be able to conduct electricity ~~by~~ i in its molten or aqueous form, the Mg^{2+} ion would be able to carry a charge to conduct the electricity.

Examiner's Comments

The candidate was able to correctly explain that the oxides of sulfur are able to conduct electricity in aqueous solution due to the availability of mobile ions.

Candidate's Response to Part (a) (ii) — Sample 3

Question No. 4(a)(ii)

Both oxides of sulfur and magnesium will not be able to conduct electricity. Even though the oxide of magnesium is an ionic compound, the ionic compound ~~i.e. solid and there are no~~ in its solid state which means that the ions are not free to carry electricity. ~~They would have to the compound would have to be molten~~ If the compound was molten they could conduct electricity. On the other hand, the oxide of sulfur is a covalent compound, meaning that there are no ions or delocalised electrons present which are required to conduct electricity.

Examiner's Comments

The candidate was able to correctly explain that oxides of magnesium do not conduct electricity in the solid state due to the absence of mobile ions.

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

(b) Figure 4 is a partial diagram of the apparatus a group of students intend/propose to use to investigate whether ethanol, aqueous ammonia and aqueous lead(II) nitrate would conduct electricity.

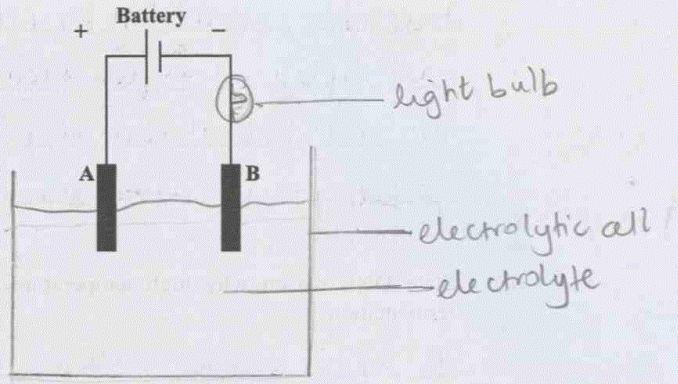


Figure 4. Partial diagram of apparatus

(i) Complete the diagram in Figure 4 in order to make it a circuit that is suitable for achieving the aim of the experiment. **(2 marks)**

Examiner's Comments

The candidate was able to correctly complete the diagram of the circuit by including the symbol of a light bulb as well as electrodes dipping into an electrolyte.

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

(ii) Classify the three substances to be investigated (ethanol, aqueous ammonia and aqueous lead(II) nitrate) EITHER as conductors OR non-conductors.

Conductors ..... lead (II) nitrate, aqueous ammonia .....

.....

Non-conductors ..... ethanol .....

Examiner's Comments

The candidate was able to correctly classify the conductors as aqueous lead (II) nitrate and aqueous ammonia and the non-conductor as ethanol.

Question 5

This question tested syllabus objectives from Section B: Organic Chemistry — 3.3, 3.8, 3.10, 3.11 and 4.2.

Responses to Part (a) (i)

Examiner's Comments

Some candidates provided an accurate definition of the term *anaerobic fermentation*. An expected response was *anaerobic fermentation is the conversion of sugars to smaller molecules like ethanol and carbon dioxide. It takes place in the absence of oxygen*.

Responses to Part (a) (ii)

Examiner's Comments

Candidates were able to state one reason why high temperatures are not suitable for anaerobic fermentation. An expected response was *temperatures exceeding 40°C denature the enzymes (proteins) in yeast, rendering them inactive*.

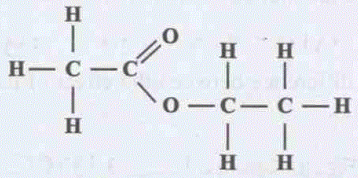
Response to Part (a) (iii)

Examiner's Comments

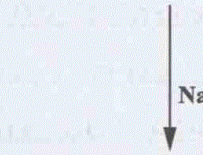
Candidates were able to write a balanced equation for the anaerobic fermentation of glucose. An expected response was $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$. Two marks were awarded to candidates who wrote balanced equations; if the equation was unbalanced, only one mark was given.

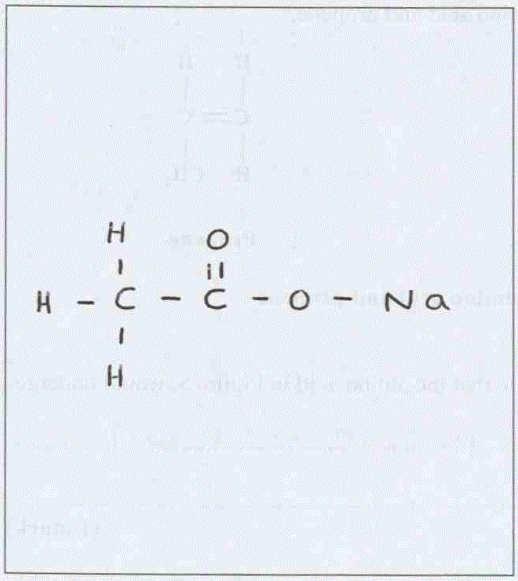
Candidate's Response to Part (b)

(b) Soaps are formed from the alkaline hydrolysis (saponification) of natural oils and fats (esters). Compound E, shown below, is an ester which is hydrolysed by aqueous sodium hydroxide. Draw the FULLY displayed structures of the hydrolysis products.

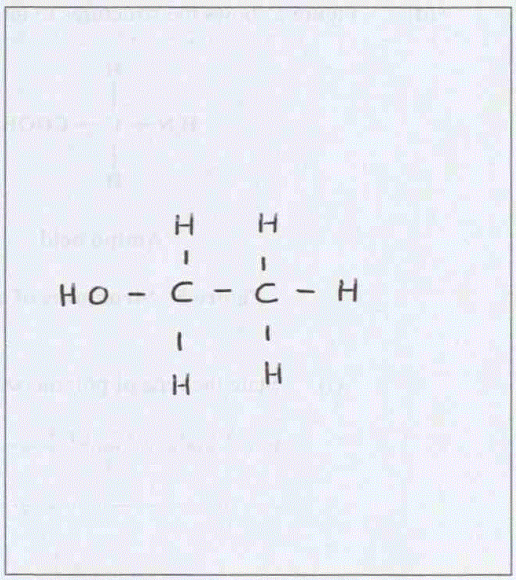


Compound E



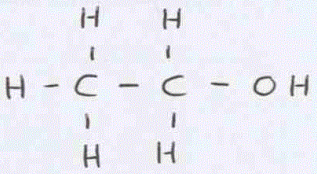


(2 marks)



(2 marks)

or



Examiner's Comments

The candidate accurately drew the complete structural formulae of the products formed from the saponification of compound E (ethyl ethanoate) using NaOH.

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

(c) (i) Name the by-product of the saponification of fats and oils.

The alcohol from which the ester was formed.

The alcohol from compound E was ethanol.

In some cases, glycerol is by-product. **(1 mark)**

Examiner's Comments
The candidate correctly identified the by-product of the saponification of fats and oils.

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

(ii) State ONE difference between the effect of using soaps and soapless detergents on hard water.

Soaps ~~are~~ do not lather well / easily with hard water. They form scum, and lime-scale.

Soapless detergents lather well / easily with hard water. They do not form scum.

(1 mark)

Examiner's Comments
The candidate correctly stated one difference between the effects of using soap and soapless detergents in hard water.

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

(i) State the type of polymerization that the amino acid in Figure 5, would undergo.

Condensation

Examiner's Comments

The candidate correctly stated the type of polymerization that the amino acid in Figure 5 would undergo.

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

(ii) State the general name for the type of polymer formed from the amino acid in Figure 5.

Polyamide

Examiner's Comments

The candidate correctly stated the general name of the polymer formed from the amino acid in Figure 5.

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

(iii) State TWO chemical tests that can be used to distinguish between propene and its polymer.

Test 1: Use of Bromine water : Propene decolourizes the red-brown colour while the polymer has no effect.

Test 2: Addition of $H^+/KMnO_4$: Propene decolourizes the purple colour of the agent and the polymer has no effect.

(2 marks)

Examiner's Comments

The candidate correctly stated two chemical tests that can be used to distinguish between propene and its polymer.

Question 6

This question tested syllabus objectives from Section C: Inorganic Chemistry — 4.3 and 5.5.

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

6. (a) Farmer Browne reaped a crop of vegetables and reported that the yield was far below what was expected. An analysis of the soil revealed that there was a deficiency of magnesium.

(i) Outline the importance of magnesium on plant health.

Magnesium is used by the plant to make the green pigment in the leaves of plants, chlorophyll. Chlorophyll is used to trap sunlight energy from the sun to be used in a process called photosynthesis a process by which plants make food. **(2 marks)**

Examiner's Comments

The candidate was able to outline the importance of magnesium on plant life.

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

(ii) Explain how a magnesium deficiency can result in the low yield of vegetables.

If there is a magnesium deficiency in the plant then the plant will make less chlorophyll so less sunlight energy will be trapped by the ~~sun~~ sun. Since less energy is trapped, there is less energy to be used in photosynthesis so less food is produced. Since less food is produced, less glucose is produced which means less glucose is stored as starch as plants which means there is less starch in the fruits and vegetables of the plant, therefore resulting in a low yield of vegetables.

(3 marks)

Examiner's Comments

The candidate explained how a magnesium deficiency can result in a low yield of vegetables.

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

(iii). State TWO other metal ions which are important to plant growth and the results of EACH deficiency.

Metal: Calcium

Deficiency: stunted growth and chlorosis

Metal: Potassium

Deficiency: Stunted growth.

Examiner's Comments

The candidate stated two additional metal ions essential for plant growth. The candidate also identified the deficiency that occurs when a plant lacks the specified metal.

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

(b) Figure 4 is a partial diagram of the apparatus a group of students intend/propose to use to investigate whether ethanol, aqueous ammonia and aqueous lead(II) nitrate would conduct electricity.

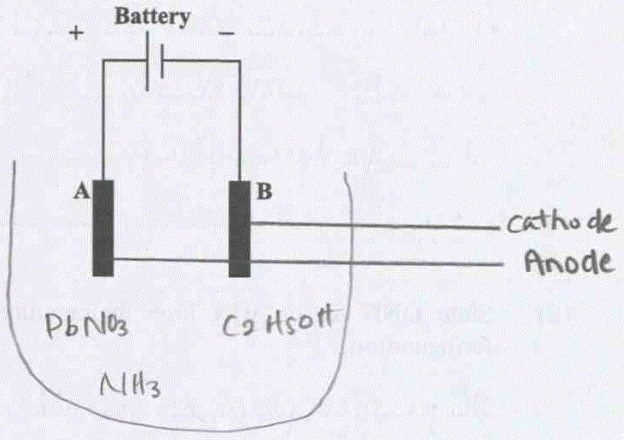


Figure 4. Partial diagram of apparatus

C2H5OH
PbNO3
NH3

H^+ N^-
Pb^{2+} NO_3^-
H^+ OH^-

(i) Complete the diagram in Figure 4 in order to make it a circuit that is suitable for achieving the aim of the experiment. **(2 marks)**

Examiner's Comments

The candidate was able to state two other examples of plastic waste that are commonly found in the seas and oceans.

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

(ii) Discuss TWO harmful effects of plastics on marine life.

Marine organisms such as turtles often consume plastic such as plastic bags as they mistake the plastic for food, this results in the death of these marine creatures. Additionally, hard or sharp plastics that are dumped into the sea often injure marine animals by cutting them, even plastic string can become tangled on an animal, strangling the creature as it grows. **(4 marks)**

Examiner's Comments

The candidate discussed two harmful effects of plastic on marine life.