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Chemistry
Paper 1
(Theory)
May, 2026
3 Hours



SCIENCE CENTRE HIGH SCHOOL
Uganda Advanced Certificate of Education
Continuous Assessments 2026
Chemistry Paper 1
(Theory)
3 Hours

INSTRUCTIONS TO CANDIDATES

All items in this examination paper are compulsory.

All responses to all item must be written in the answer sheet(s) provided.

Unnecessary crossing out of work is prohibited.

Think critically and analytically before responding to any item.

Where necessary assume:

Molar gas constant $R = 8.31$

1 mole of gas occupies 22.4dm^3 , 22400cm^3 at s.t.p

Item 1

A large chemical manufacturing plant located in the Namanve Industrial Park, near Kampala produces synthetic rubber for the East African tyre industry. One of the key steps involves the catalytic oligomerisation of small hydrocarbons. During a routine quality control, a technician isolates a volatile organic by product labelled Z. The production manager suspects that Z could be a valuable intermediate for making specialty polymers and agrochemicals but first its identity must be firmly established.

The technician performs an elemental microanalysis of a highly purified sample of Z. the results show that Z consists entirely of carbon and hydrogen, with a carbon mass percentage of 87.8% and a hydrogen mass percentage of 12.2%. In a separate experiment, Z is observed to decolorize bromine water instantly at room temperature. The vapor density of Z is determined using a Victor Meyer apparatus and found to be 41.

Further characterization is carried out using chemical tests for functional groups. A small amount of Z is shaken with ammoniacal silver nitrate solution. A clean, white precipitate forms rapidly indicating that Z belongs to a specific class of unsaturated hydrocarbons that can react with this reagent.

Task

As a student who has prior knowledge of advanced level Chemistry:

- a) (i) Using the percentage composition data from microanalysis, Deduce the empirical formula of Z*
- (ii) With reference from the Victor Meyer's apparatus, Predict the likely molecular formula of Z*

- b) (i) Help the technician categorize the isolated by product basing on the molecular formula obtained.
(ii) Draw the structural formulae and give the IUPAC names of all possible isomers of Z that are consistent with the observations made by the technician upon treating Z with the reagents Bromine water and ammoniacal silver nitrate solution.
- c) The reaction between Z and ammoniacal silver nitrate produces a white precipitate. Basing on the isomers identified in b (ii) above, identify the likely identity of Z.
- d) (i) Write a balanced chemical equation for the reaction between Z and ammoniacal silver nitrate solution.
(ii) If Z was obtained from 1-chlorobutane, provide a viable synthetic route of obtaining Z from 1-chlorobutane.
- e) Advise the technical team on the likely environmental impacts of Z and their possible mitigations.

Item 2

A research chemist working with the Uganda National Bureau of Standards (UNBS), during a routine environmental inspection near an industrial area in Jinja, collected a sample of an unknown organic compound designated compound Y. This compound is suspected by product from a local paint manufacturing plant. It is known to burn with a characteristic sooty flame, raising concerns about its contribution to particulate matter air pollution if released into the atmosphere.

In an attempt to find out the molecular identity of Y, he performed complete combustion of a 0.0627g sample of pure compound Y. the combustion yields 0.036g of water. In a separate precise experiment, 0.0209g of the same compound is completely combusted producing 29.88cm³ of carbon dioxide gas measured at standard conditions of temperature and pressure.

To further understand the behavior of Y, a large batch of compound Y was purified using steam distillation. The distillation was carried out at a temperature of 980°C and a total atmospheric pressure of 760mmHg.

After distillation, the collected distillate was found to contain 72.19g of water. The vapor pressure of pure water at 98°C was known to be 907mmHg.

Task

As a learner who has prior understanding of advanced chemistry, help the research chemist find out the molecular identity of compound Y as well as its environmental impacts and how they can be curbed.

Item 3

A research team at a pharmaceutical laboratory in Uganda is studying a naturally occurring organic compound Q extracted from a medicinal plant used in local traditional remedies. Preliminary elemental analysis revealed that Q contains 64.9% carbon, 13.5% hydrogen with the remaining percentage being oxygen. To better understand the molecular nature of this compound, a chemist measured that 1.85g of Q in the vapor state occupied 969.8cm³ at 200°C.

As part of the characterization process, the team observed that Q reacts vigorously with sodium producing bubbles of a colorless gas but shows no reaction with sodium carbonate, suggesting the presence of a particular functional group. Further, when Q is treated with anhydrous zinc chloride in concentrated hydrochloric acid, it separates into two layers after a few minutes, indicating its solubility properties and giving insight into its structural features.

In exploring potential chemical transformations, the researchers also reacted Q with acidified chromium trioxide leading to formation of a new compound A. They aimed to confirm the presence of a carbonyl functional group by reacting A with acidified 2, 4-dinitrophenyl hydrazine and examining the product including proposing a plausible mechanism for the reaction. In addition, the chemists are investigating how Q can be synthesized from an alkene under controlled laboratory conditions and want to outline the detailed mechanism for this preparation.

Task

Using the information provided in the context above, analyze and characterize the compound Q fully. In your response ensure that you calculate the molecular formula of Q, suggest names and structures of all possible isomers of Q, identify Q based on behavior with anhydrous zinc chloride and concentrated hydrochloric acid, equation for oxidation of Q as well as the preparation of Q from an alkene and the probable mechanism.

Item 4

A chemical research team in a modern laboratory is studying a newly synthesized inorganic-organic compound, compound T, which has potential industrial applications. Preliminary analysis of T has revealed that it contains 63% lead (Pb), 14.8% carbon (C), 1.8% hydrogen (H) with the remainder consisting of oxygen (O). Careful measurement under standard laboratory conditions indicates that the density of T is approximately $1.451 \times 10^{-3} \text{ g cm}^{-3}$. The research team is now tasked with determining the molecular formula and understanding the chemical behavior of T in different reactions.

In a controlled experiment, a small sample of compound T was carefully reacted with hot concentrated sulphuric acid in a fume cupboard. The reaction produced a white precipitate F and released a colorless gas G which has a strong sharp odor. Observations suggested that G is a reactive intermediate that could undergo further chemical transformations. The laboratory team is interested in exploring these transformations to understand the full reactivity profile of compound T and its derivatives.

Task

- a) *Using the given percentage composition and the measured density of compound T, determine the molecular formula of T.*

- b) Write a balanced equation for the reaction leading to the formation of the white precipitate F and hence identify gas G.
- c) Using appropriate chemical equations and reasoning, show how compound T can be transformed into propan-1-ol and propene.
- d) Predict and describe what would be observed experimentally and write corresponding chemical equations when concentrated hydrochloric acid is added drop wise until in excess to an aqueous solution of T.
- e) Describe a suitable chemical test that can be carried out in the laboratory to differentiate gas G from methanoic acid. Include the probable observations and equations of reaction.

Item 5

In a fuel research and development laboratory in Kampala, chemists are investigating a newly synthesized hydrocarbon labelled Z. to explore its potential as a clean burning fuel for domestic and industrial use. In a controlled experiment, 12cm^3 of hydrocarbon Z was carefully measured and mixed with 150cm^3 of excess oxygen in a combustion chamber. When the mixture was ignited, it burnt completely producing a sooty flame, indicative of complete combustion of carbon under certain conditions. After allowing the combustion products to cool to room temperature, the total volume of the residual gases was measured and found to be 120cm^3 . To remove carbon dioxide from this mixture, the residual gases were treated with concentrated potassium hydroxide solution leaving a final volume of 30cm^3 suggesting the presence of another unreactive gas.

Subsequent laboratory tests revealed that Z when treated with ammoniacal silver nitrate solution, formed a white precipitate, indicating the presence of a reactive halogen atom in its molecular structure. Furthermore, Z was observed to react with water in the presence of dilute sulphuric acid and a solution of mercury (ii) sulphate at 60°C forming a specific product under catalyzed hydration conditions.

Task

Using your knowledge of chemistry;

- a) Write the general chemical equation for the complete combustion of Hydrocarbon Z.*
- b) Determine the molecular formula of hydrocarbon Z based on the gas volume changes recorded during the combustion experiment.*
- c) Identify hydrocarbon Z using the reaction with ammoniacal silver nitrate solution and hence write an equation of reaction of Z with ammoniacal silver nitrate solution that leads to the formation of the white precipitate.*
- d) Write the chemical equation for the reaction of Z with water in the presence of dilute sulphuric acid and mercury (ii) sulphate at 60°C and outline a possible reaction mechanism for this transformation.*
- e) Assess the environmental impacts that may arise in use of Z and cite out the possible solutions to them.*