

**KABUWOKO SECONDARY SCHOOL**  
**ORGANIC CHEMISTRY 1: RAT 2 (S5) AND RAT 6 (S6)**  
**DURATION 2 HRS: 30 MIN**

**INSTRUCTIONS**

Attempt any **THREE(S6)** OR **TWO(S5)** of your **choice**.

You rush, you crush.

**ITEM ONE**

In kabuwoko secondary school, learners carried out a project on alkanes and researched on transporting of hydrocarbons via specialized pipelines and they conducted their research in a company designing two new pipelines; the tundra link pipeline which runs through northern Canada where external temperatures often drop to -45 Celsius and the solar pipeto pipeline which runs through a desert region where surface temperatures reach 55 Celsius. To minimize energy costs, the company prefers to transport materials in their liquid state since if a substance freezes, it blocks the pipe; if it boils, the pressure could cause a catastrophic rupture. Your lab team has provided the following physical property data for the selection of straight chain alkanes.

Hydrocarbon	State at 25C <sup>0</sup>	Boiling point	Melting point
Methane	Gas	-161	-182
Ethane	Gas	-89	-183
Propane	Gas	-42	-188
Butane	Gas	-0.5	-138
Pentane	Liquid	36	-130
hexane	Liquid	69	-95

**TASKS**

- On different graphs, plot a graph of molecular mass against melting and boiling point and use your graphs to predict the melting and boiling points of octane (12 scores)
- Explain each of your graphs above (10 scores)
- The company wants to transport propane through the tundra link pipeline, explain what state will the propane be in when it reaches the cold zone? (3 scores)
- Justify using your data if propane is a safer choice for liquid-phase transport in this environment.
- A technician suggests using pentane in the solar pipeto pipeline, identify the potential safety hazard for this decision using the data and identify which hydrocarbon would be a safer "liquid only" alternative for the desert pipeline.

**ITEM 2**

In the Albertine region of Uganda, the government is exploring ways to add value to the natural gas (predominantly methane) discovered alongside oil reserves. A local chemical engineering firm has proposed a project to convert methane into industrial solvents. One of the target products is tetrachloromethane which was historically used as a dry cleansing agent and a refrigerant, although its use is now strictly regulated due to its impact on the ozone layer. The project lead chemist Nalutaaya notes that while methane is a very stable gas, it can be forced to react with chlorine gas under specific conditions. However, she is concerned that the process is difficult to control and often results in a mixture of different chlorinated products which must then be separated. She also notes that her college Oscar deduced in his un completed research which confused him that isopentane and neopentane have different boiling points yet they have the same number of carbon atoms.

**TASKS**

- Explain deeply why methane is generally unreactive under normal lab conditions. Discuss the nature of the bonds involved and explain the specific role that UV light plays in overcoming this stability to initiate a reaction with chlorine.
- Help to clear Oscar's confusion to satisfaction.

**OUNCE I HAD 2 YEARS  
TO UNEB**

**NOW I HAVE 5 MONTHS**

**SOON HAVING NONE**

- c) Help the engineering team understand how tetrachloromethane is produced; provide a comprehensive free radical substitution mechanism.
- d) Evaluate the implications of large scale tetrachloromethane production and suggest a more sustainable alternative or a method for managing the hazardous byproducts of this reaction.

**ITEM 3**

A large agro-industrial company in Kampala, Uganda operates a modern chemical processing plant that manufactures plastic packaging materials, detergents, cooking fat, and fruit-ripening agents for farmers. The company mainly uses hydrocarbons obtained from cracking petroleum fractions. One morning, a technical fault occurred in the alkene processing section of the factory. During the incident: A colourless gas escaped from one storage cylinder,

- bromine solution stored in the laboratory lost its reddish-brown colour when mixed with the gas,
- purple acidified potassium manganate(VII) solution rapidly became colourless,
- workers observed formation of oily droplets when chlorine dissolved in tetrachloromethane was added to the gas in darkness,
- but a different reaction occurred when chlorine reacted with the gas in sunlight,
- the cooking oil processing unit simultaneously reported that liquid vegetable oil was being converted into a harder semi-solid product after treatment with hydrogen in presence of nickel catalyst,
- and farmers supplied by the company confirmed that bananas exposed to the leaking gas ripened faster than usual.

The factory chemist isolated the escaping compound and labelled it compound X. Further investigations gave the following information:

- Compound X rapidly decolourised bromine water.
- One mole of X reacted completely with one mole of hydrogen gas to form compound Y.
- Compound Y contained 85.7% carbon by mass and did not decolourise bromine water.
- When X reacted with hydrogen bromide in absence of peroxides, major product P formed.
- In presence of peroxides, a different major product Q formed.
- Passing X through steam in presence of phosphoric acid catalyst produced compound R.
- Compound R reacted with sodium metal producing bubbles of gas.
- Mild oxidation of X using acidified potassium manganate(VII) formed a diol.
- Vigorous oxidation produced carbon dioxide together with another organic acid. As a student intern attached to the factory laboratory,

**TASK**

Prepare a scientific analysis report to the management explaining the chemistry involved during the incident. (Your report should include where necessary equations, mechanisms, explanations, syntheses, calculations)

**END**

**DON'T FORGET THAT 13140014.4 SECONDS LEFT TO  
UNEB.**

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