

ITEM 1

A team of fuel quality auditors is investigating an illegal chemical storage facility in Koboko Municipality. Analysis of the confiscated chemical drums revealed two distinct groups of hydrocarbon substances: Compound Group M, having the molecular formula C_5H_{12} , and Compound Group N, consisting of halogenated and carboxylate precursors including bromoethane (CH_3CH_2Br) and sodium propanoate (CH_3CH_2COONa).

To assist the environmental enforcement team, the auditors need to determine how to separate the isomers present in Group M based on their physical properties, and evaluate how precursors in Group N can be utilized to synthesize a pure reference sample of butane (C_4H_{10}) for laboratory testing. Knowing that you are studying Senior 5 Chemistry at Arua Secondary School and have covered structural isomerism and alkane synthesis, they have approached you for expert technical advice.



Task:

As a chemistry student, write a comprehensive advisory report helping them to:

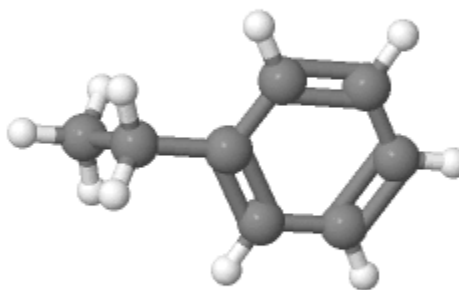
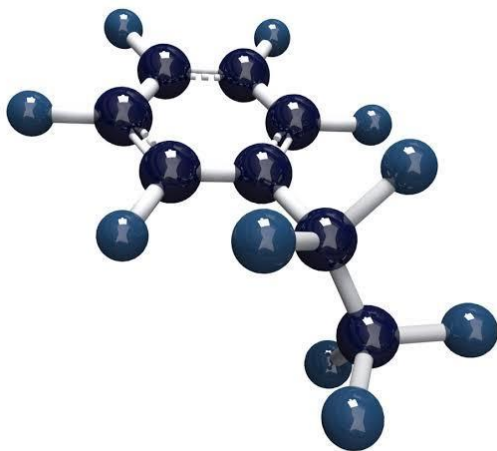
- Identify all the possible isomers in M and give their IUPAC names
- Arrange the isomers in order of increasing boiling point, giving a reason for your decision.
- Evaluate the synthetic routes for preparing pure butane (C_4H_{10}) using precursors in Group N, outline the essential reaction conditions and the reagents necessary.
- Apart from the use as fuel, suggest other uses of alkanes
- Analyze the environmental impacts associated with using butane as fuel source, and suggest mitigation measures.

ITEM 2

A group of forensic chemists are investigating organic substances they found at a suspected illegal chemical dump in Arua Municipality. They isolated two pure liquid and gaseous hydrocarbon samples, designated as Compound M and Compound N. To establish the identity and reactivity of the dump contents, elemental analysis was carried out on both samples:

- Compound M (a liquid hydrocarbon with a relative molecular mass, $M_r = 92$) was found to contain 91.30% Carbon and 8.70% Hydrogen by mass.
- Compound N (a volatile gas with a relative vapor density of 8.0) was found to contain 75.0% Carbon and 25.0% Hydrogen by mass.

To gather more information about the dump contents, the forensic team needs to determine the chemical nature and reactivity of these compounds. Knowing that you are studying Senior 5 Chemistry in Arua Secondary School and have covered organic stoichiometry, functional groups, and hydrocarbon mechanisms, they have come to you for expert advice.



Task:

As a chemistry student, write a comprehensive advisory report helping them to:

- a) Calculate the empirical formula and deduce the molecular formula for both Compound M and Compound N. Hence, give the IUPAC names and state the structural nature/functional groups present in both compounds. (Relative Atomic Masses: C = 12.0, H = 1.0)
- b) Write a mechanism for each of the following reactions;
- Compound M with chlorine (Cl_2) in the presence of ultraviolet (UV) light / heat.
 - Compound N with chlorine (Cl_2) in the presence of ultraviolet (UV) light.
 - Compound M with concentrated nitric acid (HNO_3) at $150^\circ\text{C} - 400^\circ\text{C}$.
- c) Show to them how compound M can be synthesized starting from benzene and chloromethane (or ethene).
- d) Analyze the environmental and health impacts associated with releasing or burning these compounds, and suggest practical safety precautions.