BRIDGIOUS SERIES **0752676417**

ITEM 1:

A chemistry class is investigating how different molecules behave when exposed to an external electric field using a molecular simulation. The focus is on two tetra-atomic molecules, each composed of chlorine atoms, to determine which substance would be more effective at dissolving nonpolar organic extracts.

When the electric field is applied, students notice that one of the molecules begins to rotate and align with the field, indicating an interaction, while the other molecule remains stationary and unaffected.

Further analysis reveals that **Molecule X** has a **Group III element** as its central atom, whereas **Molecule Y** has a **Group V element** at its center.

Task:

a) With an example, suggest the possible Shape of the molecule X and Y.
b) Based on their behavior in the electric field, explain why Molecule X remains unaffected, and why Molecule Y aligns with the field.

ITEM 2.

During a health science lesson, learners are introduced to the concept of oral rehydration solutions (ORS) — a simple mixture of clean water, sugar, and salt used to prevent and treat dehydration, especially in cases of diarrhea and vomiting. The class is exploring how different salts behave in water and how their ionic properties affect their suitability in rehydration therapy.

Kato is comparing the use of three salts in preparing an ORS: Sodium chloride (NaCl), Magnesium chloride ($MgCl_2$) and Aluminum chloride ($AlCl_3$)

Table 1:

Ion	**Charge (z)**	**Ionic radius (nm)**

Na^+	**+1**	**0.102**
Mg^{2+}	**+2**	**0.072**
Al^{3+}	**+3**	**0.053**

Task:

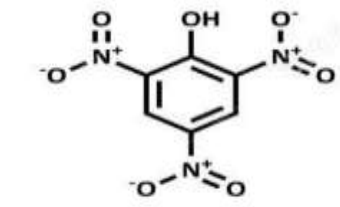
Kato is tasked with determining which salt provides the necessary ions to restore electrolyte balance effectively, without causing irritation or adverse effects due to excessive ion strength. He has been instructed to use **charge density** to predict which salt would be the most suitable.

ITEM 3:

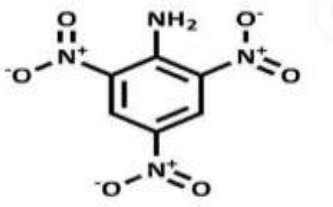
The recent discovery of additional gold deposits in Sembabule, Uganda, has led to a surge in demand for explosives to support mining operations. To facilitate access to the gold, the Ministry of Energy is seeking an explosive capable of releasing a large amount of energy to effectively break through rock formations.

Two explosive compounds have been proposed for this purpose, and the government has tasked you with determining the most suitable option.

Support material



picric acid
(trinitrophenol, TNP)



trinitroaniline
(TNA)

Combustion of the explosive's equation;

$4C_6H_3N_3O_7 + 13O_2 \longrightarrow 24CO_2 + 6N_2 + 6H_2O$

$C_6H_4N_4O_6 + 4O_2 \longrightarrow 6CO_2 + 2H_2O + 2N_2$

Bond	Bond dissociation energy
C=C	518

C-N	305
N=O	607
O-H	463
N-O	201
C=0	746
N-H	391
O=O	498
C-H	413

Task:

Evaluate and compare the bond energies of the two explosives in order to identify the one that will be most effective for use in the mining sector.

ITEM 4:

Rachel, a Senior Four student, has recently studied the topic of **trends in the periodic table.** She learned that the properties of elements, as arranged in the periodic table, significantly influence their practical uses. For her assignment, Rachel is required to explain the **variation in the first ionisation energies of the period three elements** and discuss how these variations affect their chemical reactivity.

Support material

Elements	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
1st Ionisation Energy	496	738	578	786	1012	1000	1251	1521

Task:

As a Senior Five chemistry student familiar with the concept of periodicity, use linear data representation method to help Rachel effectively address her assignment.

ITEM 5:

In the Tooro region, limestone deposits have been discovered, prompting the need to determine the quantity present in various rock samples. In this procedure, 25.0 cm^3 of hydrochloric acid solution—prepared by diluting

82.5 mL of 37% HCl (specific gravity 1.1 g/cm³)—was added to 0.482 g of rock sample containing impure limestone (calcium carbonate). The mixture was stirred until all the solid dissolved, then transferred to a 250 cm³ graduated flask and diluted to the mark with de-ionised water. A 25.0 cm³ portion of this solution was titrated with 11.8 cm³ of 0.100 M sodium hydroxide solution until neutralisation was achieved.

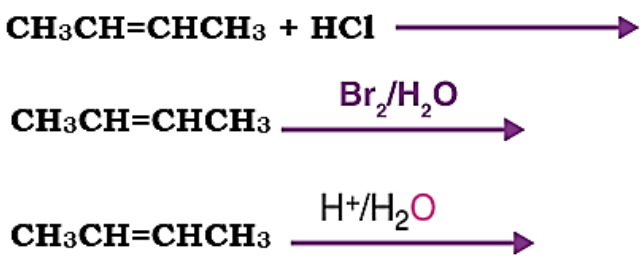
Task:

You have been assigned the task of determining the percentage purity of the limestone by utilizing the results above

ITEM 6:

A pharmaceutical manufacturing company specializing in raw materials for women's beauty products requires a specific group of organic compounds, which are proposed to be synthesized through reactions involving but-2-ene. The growing human population has led to an increased demand for these beauty products. Consequently, to enhance production efficiency, it has been suggested that a thorough understanding of the reaction mechanisms involved in synthesizing these compounds will enable chemists to optimize and accelerate the manufacturing processes.

Suuport material.



Task:

With reference to the support material complete the equations and propose suitable reaction mechanisms for synthesizing the required raw materials to serve as a basis for improving and accelerating the production processes.

ITEM 7:

To facilitate real-time visualization of molecular docking between a candidate drug molecule and a range of ligands at defined orientations on target cell receptor proteins, several simple molecules were proposed for in silico modelling. These ligands included water (H_2O), ammonia (NH_3), methane (CH_4), and boron trichloride (BCl_3).

Upon computational evaluation, water and ammonia demonstrated a stronger and more preferential binding affinity to the receptor proteins. This was attributed to their ability to engage in additional intermolecular interactions, which enhanced the stability of the ligand–receptor complexes.

Support material.

Molecule	**Bond angle**
water	104.5°
Ammonia	107°
Boron trichloride	109.5°
Methane	120°

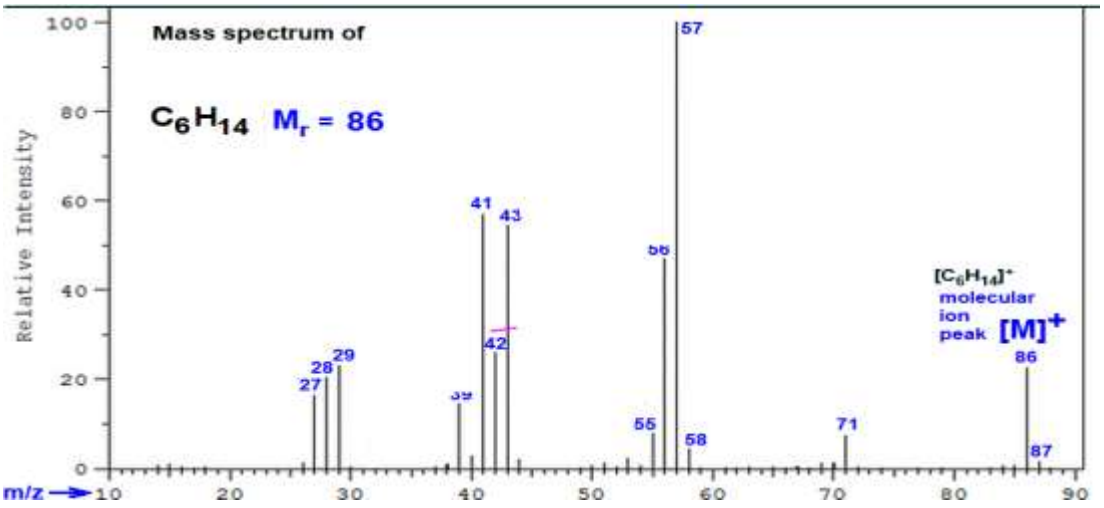
Task:

Explain how the difference in molecular geometry results into the bond angles exhibited by the molecules and what enabled the further interactions created by ammonia and water.

ITEM 8:

In Kyabando community, several learners from Mulawa Secondary School suffered from food poisoning. This prompted the police to collect food samples, which were sent to a chemist in Mulago for analysis. The chemist performed a mass spectrometry test and identified the likely cause as a hydrocarbon compound with the general formula $\mathbf{C_nH_{2n+2}}$. The mass spectrum indicated a relative molecular mass of **86**.

Support material.



Although the chemist could not conclusively determine the exact identity of the compound, he noted that it is capable of undergoing reactions involving the formation of free radicals, which could have contributed to the observed health complications. You have been invited to assist in the investigation.

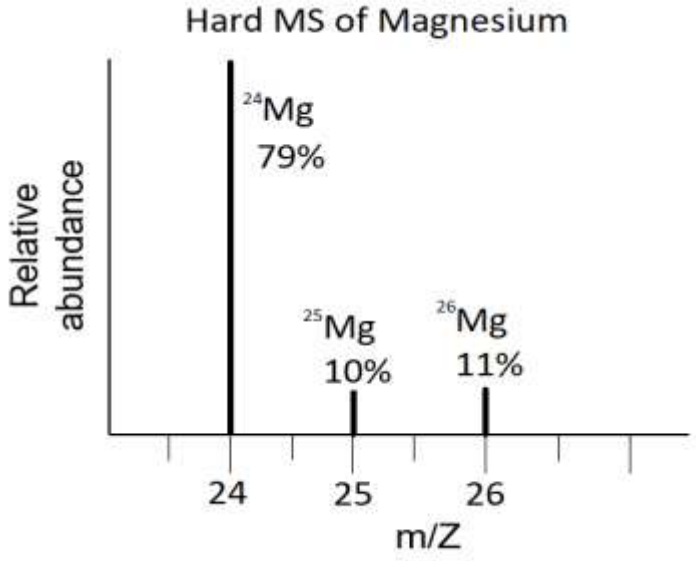
Task:

a) Explain what do the other spectral lines represent and suggest why they where not considered in the final report.
b) Basing on the existence of isomers, explain why the chemist could not definitively identify the hydrocarbon responsible for the poisoning.
c) Using the reaction of chlorine with one possible isomer in the presence of ultra violet-light, explain how radicals are formed.

ITEM 9:

Malcom works in a pharmaceutical company that manufactures magnesium supplements and magnesium hydroxide, which is used in the treatment of ulcers. A new batch of magnesium metal was delivered for product development. Before using the batch, Malcom was instructed by his line manager to analyze it using a mass spectrometer in order to determine the relative atomic mass of magnesium. This would help in calculating the precise amount of magnesium needed for sample preparation.

However, Malcom had never operated a mass spectrometer before, so he sought guidance from the manager. After receiving assistance, he successfully ran the analysis and obtained the following mass spectrum of magnesium:



Task.

a) Describe to Malcom how the mass spectrum of magnesium was obtained.

b) Help, Malcom to interpret the mass spectrum and determine the relative atomic mass of the magnesium.

c) To determine the appropriate dosage of magnesium hydroxide in a tablet for neutralizing stomach acid. The stomach secretes 500 mL of hydrochloric acid every 6 hours, with a concentration of 0.2 M. Calculate the amount of magnesium hydroxide required in a tablet to effectively neutralize this volume and concentration of acid.

ITEM 10:

During a science competition in Form 5, several statements were discussed about the applications of different substances based on their chemical properties. For example, it was mentioned that aluminium chloride is used

in the production of dyes and pigments because it forms covalent bonds with them. Another point was that trichloromethane is preferred over carbon tetrachloride in DNA extraction due to its polarity. It was also stated that water is a liquid at room temperature, while hydrogen sulphide exists as a gas.

Rachel heard these statements but felt confused and unsure about how the properties of these substances relate to their uses.

Task:

a) Explain how the above properties where acquired by the those mentioned substances to Rachel.

ITEM 11:

At the cosmetics development plant, two alcohol samples were delivered without labels. Irene, a laboratory technician, was tasked with identifying which alcohol was suitable for use in the cosmetic formulation. To do this, she decided to conduct a combustion experiment followed by analysis to determine the molecular formula of one of the unknown alcohols. She measured 30 cm^3 of the unknown alcohol vapor and combusted it in 180 cm^3 of oxygen inside a sealed combustion chamber. After complete combustion, the gases were cooled to room temperature, during which water vapor condensed and was not considered in subsequent gas measurements.

The total volume of the cooled gaseous products was found to be 150 cm^3. These gases were then passed through a tube containing soda lime, which absorbed the carbon dioxide (CO_2) produced. After this step, the gas volume reduced to 90 cm^3.

Task:

Help, Irene to determine the molecular formular of the alcohol that was combusted for proper labeling.

ITEM 12:

To enhance the efficiency of element identification, it has been proposed that stating their electronic configurations can help determine the block, group, and period to which they belong, which in turn can be used to predict their properties. Atoms A, B, and C, with atomic numbers 11, 29, and 16 respectively, have recently been discovered.

Task:

Julius, a technician at a government laboratory, was tasked with identifying these newly discovered elements and which of them would be suitable for use in a new battery technology. The new battery design requires a metal with high electrical conductivity and the ability to form stable, easily removable ions.

ITEM 13:

At the Research and Development (R&D) laboratory of a pharmaceutical company, **Dr. Sarah**, a chemist, is working on a new drug formulation. She has synthesized a new organic compound, but the exact composition of the compound is unknown. To better understand its chemical properties and structure, Dr. Sarah needs to determine both the **empirical formula** (the simplest ratio of elements) and the **molecular formula** (the actual number of atoms of each element in the molecule).

Dr. Sarah decides to conduct an experiment to determine the composition of the compound by combustion analysis. A **5.00 g** sample of the compound is combusted in excess oxygen. After combustion, the products are collected and analyzed:

The mass of **carbon dioxide (CO_2)** produced is **7.30 g**.

The mass of **water (H_2O)** produced is **3.00 g**.

Additionally, the molecular mass of the compound was determined to be **56.10 g/mol** using **spectroscopy.**

Task:

Help, Dr. sarah determine the possible organic compound**.**