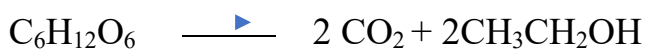


CHEMISTRY SCENARIOS 2026

ITEM 1

A renewable energy is producing bioethanol from sugar cane molasses. The bioethanol is used to power microgrids. The process involves fermenting glucose into ethanol and carbon dioxide using yeast, followed by fractional distillation. The following equilibria are available.



SUBSTANCE	EQUILIBRIUM CONCENTRATION (mol/L)
Glucose	0.2
Ethanol	0.3
Carbon dioxide	0.4

To optimize the yeast activity, the pH must be kept between 4.5 and 5.5. The team proposes use of acetic acid CH_3COOH , Sodium acetate (CH_3COONa) buffer system ($\text{pK}_a=4.74$), prepared with 0.1M acetic acid and 8.4g of sodium acetate.

The company also aims to operate a plant dealing in the production of ammonia for use in the manufacture of nitrate fertilizers used in the sugarcane plantation. The operator at the fertilizer plant heated 1.75 moles of ammonia in a 1 litre reactor vessel and equilibrium mixture was found to contain 42.9% hydrogen.

An internee at the company unintentionally added 1.2ml of 1M NaOH to the buffer solution.

Inadequate control of equilibrium conditions can result into low yields, increased costs and unnecessary release of gases in atmosphere affecting air quality. The management of the company has asked your school science club to address the concerns Task:

As a member of the science club,

- By applying the equilibrium law determine the K_c for the manufacture of ethanol and predict how continuous removal of carbon dioxide would affect the ethanol yield
- explain the effect of increasing pressure on the yield of ammonia, determine the degree of dissociation for the reaction occurring at the fertilizer plant and hence the K_c for the reaction.
- Determine the suitability of the proposed buffer system to maintain the optimum yeast activity during fermentation
- Suggest how the internee mistake would affect the suitability of the solution due to pH change.
(show your working)

ITEM 2

The chemistry of group (II) chlorides is used to make de-icing chemicals are widely used to melt ice on roads and sidewalks. The process relies on an **exothermic dissolution** where the salt releases heat upon dissolving, accelerating the

melting of ice while simultaneously lowering the freezing point of water. Salts with a lower lattice energy relative to their hydration energies yield highly exothermic values, making them exceptionally efficient at extremely low temperatures.

The Environmental Science Club committee of a certain School led by Amina, Kato and Kevin, is working on a winter-preparedness project for the school walkways. They are struggling to choose the most efficient and cost-effective de-icing raw material between Calcium Chloride and Magnesium Chloride.

The school laboratory technician provided them with the following thermochemical data to assist in their decision-making process:

Thermodynamic process	Enthalpy change (KJ/mol)
Lattice Energy of Calcium chloride	+2258.0
Enthalpy of Atomization of magnesium	+147.0
Hydration Enthalpy of Mg ²⁺	-1921.0
Hydration Enthalpy of Ca ²⁺	-1577.0
Hydration Enthalpy of Cl ⁻	-363.0
Enthalpy of atomization of chlorine	+121.5
First ionization of magnesium	+737.7
Second ionization energy of magnesium	+1450.7
Electron affinity of Chlorine	-388.6

In order to safely store and apply the best de-icing chloride, the laboratory technician also provided them with the kinetic data to be used to study how the salt's concentration affects its dissolution rate when exposed to an anti-caking moisture inhibitor (Y):



Exp.No	Initial [MC12] (mol/L)	Initial[Y] (mol/L)	Initial Rate (moll ⁻¹ s ⁻¹)
1	0.20	0.20	0.0040
2	0.40	0.20	0.0160
3	0.20	0.40	0.0080

Amina's group in their discussion found it difficult to explain how the **ionic radii** and **ionic charge** influence the values of heat of solution for two specific alkaline earth metal chlorides, the value of enthalpy of solution for the two available raw materials, how to deduce the rate constant for the stabilized mixture and any other application of the concept of enthalpy of solution in real life and they have sought for your help a knowledgeable chemists.

Task: Make a write up of a message you will use in order to Assist the Amina and Her Friend in analyzing the data to resolve their debate.

ITEM 37

Medicare Formulations Ltd, a pharmaceutical company in Kampala, has expanded its women’s health division to produce Aci-Jel Balance®, a pH stabilizing vaginal medicine used in the management of vaginitis. The product relies on a



controlled release system containing ethyl ethanoate, which hydrolyses in the body to generate small amounts of ethanoic acid essential for preventing harmful microbial growth. During checkup, the chemists must verify the efficiency of the ester production step, because the yield of ethyl ethanoate determines how well the final medicine will perform. The key step is the esterification reaction: $\text{CH}_3\text{COOH}(\text{l}) + \text{CH}_3\text{CH}_2\text{OH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOCH}_2\text{CH}_3(\text{l}) + \text{H}_2\text{O}(\text{l})$, $\Delta H = \text{negative}$

To check product consistency, a batch test was conducted with 2.00 mole of ethanoic acid mixed with 10.00 moles of ethanol and sealed in a glass tube. The tube was kept in a water bath at 60°C for several hours. After cooling, the tube was broken into cold water and the resulting mixture required 290 cm^3 of 0.200 M sodium hydroxide during titration to neutralize the unreacted ethanoic acid at equilibrium. Chemists also prepared a 0.010 M ethanoic acid solution with known acid dissociation constant $K_a = 1.8 \times 10^{-5}$. Because the final product must safely maintain pH inside the human body, the company designs a buffer system made from ethanoic acid and sodium ethanoate and must know how it works. Those that the company manager and community is concerned about possible environmental impacts that may emerge from the industry.

You have been contacted for help.

Task

As a learner of chemistry guide the company on how to; (a) Calculate the equilibrium constant for the esterification reaction and predict the extent of the reaction. (b) Explain how both the amount of ethyl ethanoate produced, the position and rate of attainment of equilibrium would change if:

- i) More ethanol is added to the reacting mixture.
- ii) Water is removed during the reaction.

ITEM 4

In the rural district of Luweero, central Uganda, a community-led water treatment initiative operates a small filtration plant drawing water from local underground water sources and boreholes to supply clean drinking water to over 500 households. This water is hard due to high levels of calcium ions (Ca^{2+}) from dissolved limestone, leading to scale build-up in pipes and kettles, which increases maintenance costs and reduces water flow efficiency. To address this, the plant uses sodium carbonate (Na_2CO_3) to soften the water by precipitating calcium carbonate (CaCO_3). However, inconsistent dosing of the water with sodium carbonate has resulted in incomplete removal or excessive sludge formation. This has led to clogging of filters and raising operational expenses.

Water samples show initial concentrations: $[\text{Ca}^{2+}] = 0.005\text{ M}$, and the water engineer has proposed to add 1.5g of sodium carbonate for each **liter of the water. The solubility product at 25°C of calcium carbonate is 3.8×10^{-9} .**

Tasks:

As a student of Chemistry, use your knowledge of equilibria to a) Determine the core problem or challenge in the water treatment process proposed by the water engineer.

- b) Explain how the additive, sodium carbonate, functions in treating the water.
- c) Identify dangers, or side effects of the current approach, where the amount of sodium carbonate used per liter of water keeps changing and hence suggest mitigations.

Item 5

An upstart pharmaceutical company is in the middle of a serious product development crisis. They are formulating a new paediatric oral suspension medicine containing calcium hydroxide as an antacid and calcium supplement. However, the formulation team has encountered major problems: the calcium hydroxide is not dissolving sufficiently in the aqueous base, resulting in poor bioavailability, inconsistent dosing, and visible sedimentation in the bottles. This has delayed regulatory approval and risked the entire project.

The product development team in the laboratory has determined that the solubility product (K_{sp}) of calcium hydroxide at 25 °C is 5.5×10^{-6} using Chemistry data books. Management urgently needs a scientific explanation of why calcium hydroxide is only sparingly soluble and how its solubility can be manipulated, they think that knowing the pH of its saturated solution will help in manipulating the solubility, besides your recommendations on how to increase its solubility in the formulation, and broader insights into how the solubility product concept can be applied to solve other challenges in medicinal product development they may encounter later in their work. The Head of Formulation has invited your A-Level Chemistry class through the head of Chemistry department, to analyse the situation and submit expert recommendations before the critical reformulation meeting scheduled for next week.

Task

As a student of Chemistry and top in your class, prepare a technical report for the product development team at the meeting.

Item 6

A pharmaceutical company is formulating a new paediatric oral rehydration solution (ORS) and antiseptic throat spray for the local market. The formulation must have a safe, stable, and effective pH to ensure proper hydration, antimicrobial activity, and palatability for children. They have met with a few challenges.

The development team has prepared trial batches using hydrochloric acid, and ethanoic acid, to adjust acidity. However, the pH of the batches is inconsistent, affecting both the taste and the stability of the active ingredients. The development team manager needs a clear scientific explanation of the differences between acid categories such as those in which hydrochloric and ethanoic acids fall; accurate pH calculations for both types of solutions, factors that can influence the pH of weak acid solutions, and evidence-based recommendations on how to achieve and

Bamwite Raphael - 0773289583 maintain the target pH range (4.5 – 5.5) in the final product before proceeding to clinical trials.

They have sought help from your teacher who has then delegated the task to you to produce a concise technical report for her to deliver to the manager of the development.

Task

Prepare a technical report for the teacher to give the manager of the production team.

(The dissociation constant for ethanoic acid as 1.74×10^{-5} at 25 °C) –

Item 7

A Youth group has set up fruit juice processing company in Kumi District using the funds they got from the government “Parish Development Model”. They are facing a major product-development issues. Their new ready-to-drink passion fruit and orange juice blend has unstable pH levels during storage and transportation, leading to rapid spoilage, changes in taste, and frequent customer complaints. The natural ethanoic acid content in the juice is causing the pH to drop too low over time, while occasional pH spikes are also occurring due to minor contamination.

The quality control laboratory has determined that the juice already contains 0.01 M ethanoic acid. Some members in the company have proposed separately adding more ethanoic acid (vinegar) or sodium ethanoate to stabilise the pH at 5.6. The company needs to know exactly how much sodium ethanoate must be added to 20 litres of the juice to achieve and maintain this target pH at 25 °C (Management also wants a clear scientific explanation of how this pH maintenance

mixture works, whether using ethanoic acid alone or sodium ethanoate alone would stabilise the pH, and other practical applications of solutions that stabilise pH, in agriculture or industry before approving the new formulation.

The production manager has invited the science club of your school to help analyse the situation and provide expert recommendations ahead of the critical reformulation meeting next week.

Task

Prepare and write the technical report you would present as the head of the science club of your school to a meeting with the youth group's production team. (K_a of ethanoic acid = 1.74×10^{-5} ; Na = 23, C = 12, H = 1; O = 16) -

ITEM 8

A pharmaceutical company reported poor dissolution of an active drug ingredient during production. The solvent used was supplied in a

container labeled M claimed to be a carbonyl compound but the senior quality analyst suspects it to be contaminated with an alcohol. The suitable compound to be used should possess a keto function group to allow solubility to form a homogeneous mixture in the syrup tanks. Basing on your organic reactions, the industrial chemist has contacted you to analyze the supplied compound, predict its solubility and acidity hence identify M basing on its structure and reactions

You have been provided with the following;

Compound M which is the solvent supplied to the company and Common reagents for identity of organic compounds Task:

Design and carry out a scientific investigation to determine the nature of the organic compound and use your findings to explain to the senior quality analyst where it should be used or not advise the company on the causes of poor dissolution of the ingredients used

ITEM 9

A beverage manufacturing company produces almond flavored soft drinks. Customers have recently complained that the new batch lacks the expected almond. The quality control department suspects that the flavoring ingredient is either not extra pure or used wrongly. A junior laboratory technician in charge of the quality control room suspects that he might have interchanged the bottles **containing phenol and Benzaldehyde** contributing to the poor quality of the final products and scared of losing the job

You have been contacted by overall manager of the quality department to analyse the sample of the soft **drink labeled T** of that batch and use your results to help the manger to make fair decisions on either to chase the lab technician or not
Task:

Design and carry out a scientific investigation to identify the active functional group in food sample T and help the manager make good decisions

Item 10

A certain pharmaceutical company located in Mbale is aiming at developing a new Non-Steroid Anti-inflammatory Drug (**NSAID**) to cure fever, cough and bacterial infections. This had been brought about due to the increased cost of the imported drugs which the locals cannot afford. The drug is expected to contain an active ingredient **4-hydroxybenzaldehyde** which contains phenol and aldo functional groups. The production manager in charge of the syrup room must first analyze the ingredients but the team lacks knowledge about the structure, possible synthetic routes, appropriate mechanisms and preparation principles. The production team is also concerned of the **poor solubility and**

stability of the imported drugs reducing their effectiveness and causing environmental harm when disposed and therefore aims to create a drug that is effective and environmentally safe and have contacted you for help.

Task:

- a) i) Predict the solubility and acidity of the drug basing on its major functional groups hence evaluate the product ii) Comment on the probable melting point of the drug to ensure its stability during high temperature processing following the phenol functional group
- b) Propose synthetic route and suitable mechanism for the first step in the production of the drug from benzene as a raw material
- c) Show how the drug can be converted to **an ester** and a **cyano hydrin** compound
- d) Propose appropriate mechanisms for the reaction of the drug with;
 - i) Acidified hydrazine (NH_2NH_2) solution ii) Sodium hydrogen sulphite solution
- e) Suggest suitable mitigations for the environmental risks of the production process

Item 11

A certain town in western Uganda faces concerns over water pollution from agro processing industries especially during cocoa harvest season. Waste water from the processing plant often contains compounds including acids, alcohols, carbonyl compounds which harm aquatic life if not treated. Your chemistry class is concerned of the matter and wishes to analyze the waste organic compounds and convert them into valuable products. Analysis shows that the water (husks) contains propan-1-ol, ethanoic acid from protein break down, and Ethanol. To address water pollution challenges and create revenue streams, your team plans to,

1. *Predict the solubility of propan-1-ol in water streams*
2. **Convert propanol to;**

-Butanoic acid

-Butan-2-ol

-2,2-dichloro propane

3. **Synthesize;**

-2-hydroxy propanoic acid from ethanol -

Benzene from Ethanal

4. **Explore mechanisms for the following;**

-Conversion of ethanal to ethanol-2, 4-dinitrophenyl hydrazone

-Conversion of propan-1-ol to propylethanoate

You have been tasked by your teacher to design feasible chemical processes, explain the underlying organic chemistry and propose sustainable solutions while maintaining profitability **Task:**

As a chemistry student, prepare a systematic write up to address the plans of the team

Item 12

A plastic company located in western Uganda aims at producing variety of modern plastics to increase sales while conserving the environment. The industrial specialist sourced many organic compounds provided in **table 1** for use in the

production process. A team of chemical engineers must explore the **structures of compounds, their function groups** and possible reaction mechanisms before the actual production process proceeds. You have been contacted for help Table 1

Compound	IUPAC name
O	Benzene
P	Phenyl ethene
Q	1-chloropropane
R	Methyl benzene

Task:

As a member of the production team;

- Analyze the structures of the organic compounds and their functional groups
- Compare the stability of benzene and methyl benzene based on their structures
- Propose suitable synthetic routes to;
 - Convert P to phenyl ethanone
 - Convert Q to propyne
 - Synthesize R from benzoic acid
 - Explore mechanisms for;
 - conversion of O to dipheny methanone
 - conversion of Q to butanitrile
 - conversion of P to 1-pheny ethanol
 - conversion of P to 1-pheny ethanol

Reaction of

O with nitric acid

- Discuss the effects of the compounds to the environment and possible mitigations

Item 13

A group of forensic officers working in URA were analyzing compounds for use in making food additives imported in Uganda. One of the compounds, T with molecular formula **C₃H₇Br** was suspected to have very many analogues. Identity of T is required before approval by UNBS to ensure food safety. During laboratory tests, treatment of T with aqueous potassium hydroxide and heat produced Q which upon oxidation using potassium dichromate VI and heat yielded R that gave yellow precipitate with Brady's reagent and Iodoform test. You have been contacted to explain the underlying organic reactions and propose suitable solutions to the investigation.

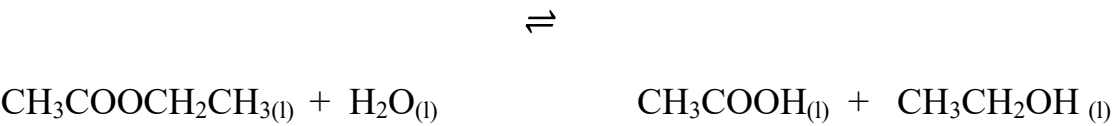
Task:

- By writing all the possible isomers **of Identify T** based on its reactions
- Explore all the reactions described, indicate suitable equations with appropriate conditions and mechanisms where possible hence identify **Q,R** and the yellow **precipitates formed**
- Show how T can be converted to **but-1-yne** and how it can be produced from ethanol
- Propose mechanisms for reaction of R with **KCN in dilute sulphuric acid** hence name the product
- Write all the possible isomers of **Q** hence distinguish them(*indicate reagent ,observations and equations where possible*)
- Evaluate the **applications** of the above identified products in industry and health

Item 14

Some waste material can be transformed into other useful products for use in a society.

Residents in an area were advised by local investors to make use of some of the extracts from waste materials containing esters (ethyl ethanoate) and transform them into ethanol and ethanoic acid by reacting them with excess water. The equation for the reaction that takes place is;



The members were not sure whether they had to carry out the process under ordinary temperature or not. They were also concerned to know how the reaction would progress basing on their raw material ethyl ethanoate so that they can plan effectively. Later they noticed that the process was slow. Some members suggested that they should seek advice from some technical people. They contacted the laboratory technician in one of the schools in the area, asked for help and provided them with some data to use. He informed them that in order to improve on the process they should;

- (i)

Use information in thermochemical data in **set 1** and consider energy profile diagram for the process in order help them improve on the reaction.
- (ii)

establish the relationship between the progress of the process and amount of raw material using set **data 2** which was obtained by investigating on how the amount of one of the products formed during the process varied with time when the mixture was titrated with sodium hydroxide solution.
- (iii)

Add little amount of acid to the reaction mixture.

Data set 1 .

Compounds	Enthalpy of formation/kJmol ⁻¹
Ethyl ethanoate	-480
Water	-285.8
Ethanol	-277.7
Ethanoic acid	-484

Data set 2

Time/min	0	5	10	15	20	25	30
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Volume of sodium hydroxide solution/cm ³	30	23.4	18.3	14.2	11.1	8.7	6.8
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Task

Analyze the data and the information provided by the laboratory technician and help the community members address their challenge.

ITEM 15

The presence of some dissolved substances may affect the physical properties of the solvents.

Residents in a certain town started experiencing unusual properties from some of the water sources used in the community, more fuel is used in boiling water than before. They suspected the water to be contaminated by some products from pharmaceutical industries producing food additives. Matters were reported to the environmental officer who requested the laboratory technician to carry out analysis on water samples, and the data set below was obtained.

Water sample	Elevation in boiling point/ ⁰ C	Mass of water used/g
X	0.07	80

The boiling point constant (K_b) for water is $0.52^{\circ}\text{C mol}^{-1} \text{ kg}^{-1}$ and molar mass of the compound suspected to contaminate water is 118g. It's relatively safe to continue using the water for some time if the concentration of the compound in water does not exceed approximately 16.0 g per litre.

The boiling point of water is 100°C and density of water is 1.0 g cm^{-3} .

Data analysis on the suspected food additive suggests that it contains the elements carbon, hydrogen and oxygen in the ratio of 2:3:2 respectively.

Task

- Analyze the formula of the food additive.
- Assess the challenges faced by the residence.

ITEM 16

Industrial chemical processes are essential in production of some materials for use in society .

Members of senior five class under their chemistry teacher organized a study tour to agrochemical and manufacturing industry in order to align their subject content to the industrial applications. They explored several products among which includes abrasives and medicines. They were told aluminium oxide and silicon dioxide were used in making abrasives whereas magnesium oxide had applications in area of medicine and agriculture. She also informed them that the excess

aluminium oxide and silicon dioxide are eliminated using sodium hydroxide solution while hydrochloric acid is used to remove excess magnesium oxide. After the tour the teacher then presented his questionnaire to the learners at school which had the following concerns why the following are used;

- (i) aluminium oxide and silicon dioxide.
- (ii) magnesium oxide,
- (iii) sodium hydroxide solution and hydrochloric acid.

He also told them to evaluate application of magnesium oxide.

The learners failed to provide sufficient information because lacked adequate knowledge.

Task

Help the learners address their challenge.

Item 17

Physical properties of substances play important role in making choice for their use.

Tin and copper have wider application to the society. Tin has application in food industry and electronic industry .A group of young entrepreneurs ventured into a project of melting metals and form solid mixtures which have more improved properties than those of the individual metals for better use. Their preference was to select two metals among lead, tin and copper. They failed to make choice and therefore decided to consult laboratory technician for help. He provided them with some data to use and make their choice.

Elements	Tin	Lead	Copper
Atomic radii/nm	0.162	0.175	0.128
Melting points/ ⁰ C	232	328	1356

He suggested that they should use copper and tin. He also told them for better understanding they should have knowledge on the impact on health by the two metals. It’s also important to understand how the elements provided interact with air, water and chlorine. The entrepreneurs lacked sufficient knowledge and therefore requested for a write-up for better understanding. The laboratory technician has identified you as a potential learner who can guide the entrepreneurs.

TASK

Write a report you will use for guidance.

Item 18

Organic compounds are important material used in manufacture of some of items used by community.

Members of science club in Wakiso district under their chemistry teacher organized a tour to a manufacturing industry processing organic product. The production manager informed the students that they involve in manufacture of variety of products using benzaldehyde as the raw material. The raw material is transformed into benzene used in preparing of an organic compound X used in making of the polymer polyphenyl ethene. The raw material is also used in making of benzaldoxime ($\text{C}_6\text{H}_5\text{CH}=\text{NOH}$) a product used in chemical industry.

The production manager emphasized that key areas involve having knowledge in knowing the physical properties of compound X in relation to its formation and also writing equations;

- (i) using arrows leading towards formation of compound X and benzaldoxime.
- (ii) for reaction pathways leading towards formation of compound X from the raw material, and formation of raw material from benzene. Evaluate the polymer formed in this process.

TASK

- (a) Write a report to address the key areas of the production manager.
- (b) Evaluate the impact the polymer on the environment.

Item 19

Organic compounds are essential materials used to produce variety of products used in society.

A group of investors decided to use the product formed from the community by fermentation of carbohydrates as a raw material and transform it into other useful products for use in the community. They decided to prepare ;

- Compound Y used in formation of propanone sodium bisulphite $(\text{CH}_3)_2\text{C}(\text{OH})\text{SO}_3\text{Na}$ a product used in food industry.
- Benzene an important industrial organic solvent.
- Diethyl ether used as an organic extracting solvent.

The investors approached the laboratory technician for advice. He informed that in order to implement the project effectively the investors should have knowledge on

- (i) physical properties of compound Y in relation to its formation from the raw material.
- (ii) writing equations using arrows to show how propanone sodium bisulphite $(\text{CH}_3)_2\text{C}(\text{OH})\text{SO}_3\text{Na}$ and diethyl ether are formed.
- (iii) writing equations for reaction pathways leading towards formation of benzene and propanone sodium bisulphite $(\text{CH}_3)_2\text{C}(\text{OH})\text{SO}_3\text{Na}$ from the

raw material.

The investors failed to have a clear understanding and therefore requested for a write-up. The laboratory technician has asked you to give guidance to the investors.

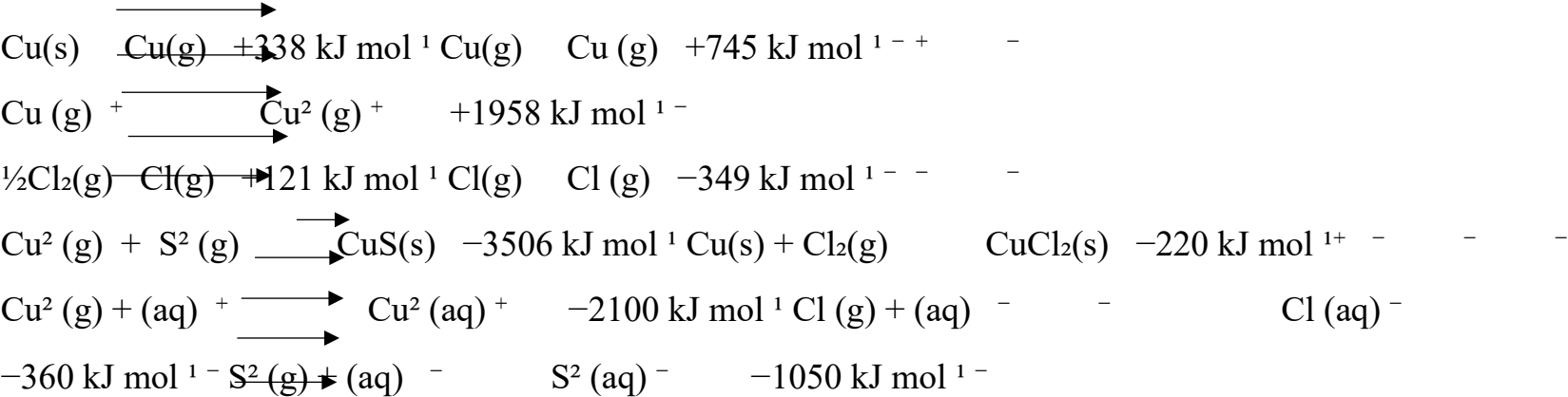
Task

- (a) Write a report and give guidance to the investors.
- (b) Evaluate the impact of diethylether to the environment.

Item 20

Heavy Metal poisoning in human beings is related to the solubility of their salts in water and they can be removed from the body by use of chelating agents. A rural community around Kilembe, a copper mine experienced a high prevalence of liver disease due to copper poisoning. The community depended on water from a nearby river whose water on analysis by an environmental chemist showed high levels of Copper (II) chloride and Copper (II) sulphide. The community health team wants to know the salt responsible for the liver disease. The environmental chemist in one of the local council meetings suggested that EDTA, a chelating agent whose half life was not known, could be effective in healing liver disease and gave the community health team the following data:

Data Set I



Data Set II

Concentration of EDTA (mol dm ⁻³)	1.48	1.45	1.43	1.41	1.38	1.36
Time (hours)	1.0	2.0	3.0	4.0	5.0	6.0

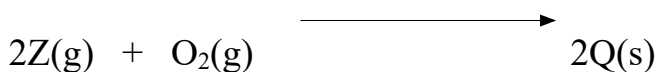
Your chemistry teacher came across this information in one of the community meetings.

Task: As a student of Chemistry analyse and interpret the data for the community health team.

Item 21

Knowledge of equilibrium reactions is very important in industrial processes in optimizing reaction conditions. A manufacturing company dealing in fertilizers to improve agricultural yield has received notices threatening to have its

operations closed because of the fumes it discharges to the environment. A laboratory report from an environmental chemist indicates that the fumes from the company's plant contain gas Z, which is 50.05% sulphur and the rest oxygen. The Quality Assurance Manager for the company suggested that they can convert Z to another gas Q according to the following equation:



During the conversion, 3 moles of gaseous Z and 1.5 moles of oxygen were introduced into a vessel and heated to 400°C. When equilibrium was established, the vessel was found to contain 0.5 moles of oxygen. When the temperature was raised to 500°C, the mixture was found to contain 40% of the initial Z at equilibrium.

The Company's Management wants to know; a) Molecular formula of Z

b) How factors like pressure, catalyst affect the rate of reaction and whether the reaction is exothermic or endothermic.

c) Applications of the above reaction.

Task: Your laboratory technician came across this information but he is challenged.

Task: As a student of chemistry, analyse the data provided to address the concerns of the company. (Hint: Molar Mass of Z = 64)

Item 22

The chemistry of group (VII) elements is very important in the plastic industry. A group of Chemistry students under the Science Club visited a plastic plant and observed some of the plastics manufactured from Fluorine and Chlorine and their tour guide informed them the plant exploits the reactivity of group (VII) elements which may be determined by a number of periodic properties. The properties include;

Element	F	Cl	Br	I
Atomic radius (nm)	0.071	0.099	0.114	0.133
Boiling Point (°C)	-188	-35	59	184

Among the reactions the plant incorporates in the manufacture are; reaction with metals, water and alkalis.

The plant's Management is interested in how physical properties affect reactivity, chemical reactions that occur, applications of group (VII) elements and the possible environmental health concerns.

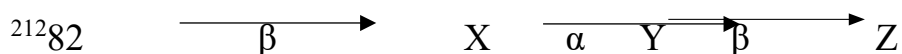
When the students returned to school, their chemistry teacher wanted them to give a report to address the plant's Management concerns but they have found it difficult and have approached you.

Task: As a student of Chemistry, make a write up to address the plant's Management concerns.

Item 23

The demand for electricity is increasing in the manufacturing sector and to address this a nuclear plant has been set up in one of the cities. In one research the technical team of the plant subjected the radiation from a radioactive source to an electric field and took note of the various deviations. In the second research the team used $^{212}_{82}\text{Pb}$ and they observed that it underwent the following radioactive decay;

Pb



In the team's third research, it noted that ${}^{232}_{90}\text{Th}$ emits a total of Six alpha particles and four beta particles in its natural decay sequence. In the last research the team used a sample of a radioactive isotope with a half life of 3hours and found it to have an activity of 1000 counts s^{-1} at a certain time. The plants management wants to Know; the type of radiations emitted by radioactive elements and their properties, Identity of elements X, Y and Z and their groups in the periodic table, the Identity of the last element formed by ${}^{232}_{90}\text{Th}$ in its natural decay, activity of the element in the last research after 2hours and the health implications of applications of radioactivity. Your teachers Came across this information.

Task: As a student of Chemistry make a write up to address the Concerns of the management team of the plant.

Item 24

Farmers in a certain Community have faced a challenge of delayed fruit ripening to match the market trends. A manufacturing Company has decided to produce ethene a fruit ripener from butan-1-ol and at the same time produce propanone used as a solvent from propene.

As a way of mitigating the side effects of butanol unreacted raw material; butan-1-ol is reacted with concentrated Sulphuric acid at 180°C and propene with benzene. The Company's Management wants to Know; Suitability of its products to their applications, Synthetic pathways for its products, an evaluation of mitigation reactions for Un reacted raw materials with equations and the associated environmental impacts of application of its products.

Your laboratory technician Come across this information.

Task: As a student of Chemistry, analyse and interpret the data presented to address the Concerns of Management.

Item 25

The Chemistry of Organic Compounds is Widely utilized in the manufacture of flavours that improve the Scent of perfumes. S.5 Students Under the Science Club would like to produce a flavour and a solvent Used to remove Organic Stubborn Stains. They intend to use phenylethanone as a flavour and propan-2-ol to make a solvent. In a mitigation reaction the excess products, phenylethanone and propan-2-ol can be reacted with 2,4-dinitrophenyl hydrazine and concentrated Sulphuric acid respectively.

To match the market demands the students were advised to use a locally made ethanol as a raw material for both processes. The S.5 students are Challenged and they have come to you.

Task: As a Chemistry Student help the S.5 Students to;

- Understand the Suitability of their products for their applications.
- Assess the Synthetic pathways for their products and evaluate mitigation reactions with equations.
- Know the associated Environmental implications of their products.

. As part of efforts to reduce greenhouse gas emissions and increase the use of clean energy technologies, a renewable-energy company is investigating the production of hydrogen fuel for use in fuel-cellpowered charging stations. Hydrogen is considered a promising alternative fuel because it can generate electricity without producing carbon dioxide.

Before constructing a pilot production plant, the company is evaluating a reaction that produces hydrogen gas from two reactants, X and Y. They have been advised that the rate constant above $2.0 \times 10^{-2} \text{ mol dm}^{-3} \text{ s}^{-1}$ and enthalpy of reaction above -150 kJ mol^{-1} represent an efficient production process.

The reaction is represented by the equation:



A series of experiments were conducted at 298 K and the following results were obtained.

Table 1: Initial Rate Data

Experiment	[X] (mol dm ⁻³)	[Y] (mol dm ⁻³)	Initial Rate (mol dm ⁻³ s ⁻¹)
1	0.10	0.10	2.0×10^{-3}
2	0.20	0.10	8.0×10^{-3}
3	0.30	0.10	1.8×10^{-2}
4	0.10	0.20	4.0×10^{-3}

Table 2: Thermochemical Data

Species	ΔH_f° (kJ mol ⁻¹)
X	-120
Y	-250
Products	-670
H _{2(g)}	0

The company also wants to investigate the factors that affect the rate of hydrogen production and company intends to establish production units in remote communities where efficiency, safety, and sustainability are critical.

Task

- a) Analyse the data provided and use it to comment on whether the reaction can actually be used for electricity generation and help the company assess the efficiency of the production process.
- b) Explain the factors that may affect the production rate of the fuel.
- c) Analyse the importance of the principles in the experiments conducted in real life and make a recommendation on the quality of a good fuel the company should consider.

2. A bottled mineral water company sources its water from underground limestone layers. The water naturally contains dissolved calcium hydrogen carbonate formed through the interaction of rainwater, carbon dioxide, and limestone rocks.

Recently, customers have complained that some bottled water develops a white precipitate after prolonged storage, particularly in bottles stored in warm environments. The company's quality assurance team suspects that changes in the equilibria involving calcium carbonate are responsible.

The company carried out investigations under different storage conditions.

Table 1: Ionic Concentrations in Three Bottled Water Samples

Sample	[Ca ²⁺] (mol dm ⁻³)	[CO ₃ ²⁻] (mol dm ⁻³)
A	1.0 x 10 ⁻²	2.0 x 10 ⁻⁷
B	2.5 x 10 ⁻²	3.0 x 10 ⁻⁷
C	4.0 x 10 ⁻²	5.0 x 10 ⁻⁷

For calcium carbonate, $K_{sp}=4.0\times10^{-9}\text{ mol}^2\text{dm}^{-6}$

The company wants to determine the causes of precipitate formation and identify suitable storage conditions that maintain water quality but lack expertise.

To improve water quality, the company is also investigating the use of a solvent extraction process to remove traces of an organic contaminant, X, from the water before bottling.

The distribution coefficient of contaminant X between an organic solvent and water at 25°C is 4.0. A 100 cm³ sample of contaminated water containing 0.80 g of X is shaken with two successive 25 cm³ portions of the organic solvent and allowed to reach equilibrium.

Task:

- a) Analyse the data given for Samples A, B and C and use it to identify and explain the bottled water samples which are more likely to develop visible deposits during storage.
- b) Determine the amount of contaminant X remaining in the aqueous phase after extraction and interpret the significance of your results in relation to water quality and purification.
- c) Explain the factors that might have affected precipitation in the bottles and how knowledge of ionic equilibria and physical equilibria is applied in real life.

ITEM 26

Water treatment and waste management systems are key in improving public health and environmental sustainability. A rapidly growing municipality in Uganda relies on chlorine for disinfecting drinking water, but recent expansion plans have raised concerns about the safe handling, storage, and disposal of chemicals used in water treatment and nearby industries. Several industries operating within the municipality use or produce substances containing chlorine. These include

- Sodium chloride (NaCl)
- Aluminium chloride (AlCl₃)
- Tin(IV) chloride (SnCl₄)

- Chlorine (Cl₂)

During stakeholder meetings, engineers, environmental officers, and public health officials observed that these substances behave very differently during storage, transport, and use. For example, some exist as solids with very high melting and boiling points, while others are volatile liquids or gases. Some react readily with water to produce acidic solutions, while others dissolve with little or no chemical change. Similarly, when treated with sodium hydroxide during waste treatment, they undergo entirely different reactions.

To make informed decisions about chemical selection, handling, and disposal, the municipality needs to understand the above behaviors of the compounds but lack the skills and knowledge. This understanding would be used to develop guidelines for chemical use in water treatment, industrial processes, and environmental management.

Task

- Help the municipality to analyse and understand the behaviors of the compounds.
- Assess the use of chlorine by the municipality.

ITEM 27

Different oxides are used in industries such as cement, fertilisers, and ceramics, where their properties affect heating, safety, and environmental pollution. Farmers near a certain factory reported crop damage and faster corrosion of iron sheets, while workers and engineers raised concerns about irritating oxide fumes and the high temperatures required to process some oxide materials. Concerned about the increasing complaints, the district science and environment committee organised a joint industrial inspection involving chemists, environmental officers, and Senior Six chemistry learners from neighbouring schools. Samples of several oxides formed by Period 3 elements were collected from different industrial processes and analysed in the laboratory. The learners were provided with the following information.

Oxide	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	SO ₃
Melting Point (°C)	1275	2827	2007	1607	30

During the inspection, the learners observed that some oxides reacted vigorously with water, some dissolved only in alkaline solutions, while others contributed to acidic emissions in the atmosphere.

The district committee later requested the learners to prepare a scientific report that could help industries improve safety, reduce pollution, and select suitable oxide materials for industrial use.

Task:

As one of the senior six learners of chemistry:

- Explain why some oxides formed fumes while others require high temperatures to process.
- Analyse and explain the observed reactions of the oxides during inspection.
- Assess the environmental, health, or industrial implications associated with the production and use of the oxides investigated, and recommend suitable safety measures.

ITEM 28

Many useful substances are obtained from organic compounds and are often converted into other useful substances through different chemical reactions. Recently, in a chemical manufacturing company which uses propan-1-ol and ethyne

as raw materials to produce products required by their customers. The quality assurance team advised that the boiling points of the raw materials and the products formed should always be analysed to avoid likely explosions but the company lacked expertise.

A chemistry learner who visited the factory during a science innovation exhibition became interested in how these simple organic compounds could be converted into more useful industrial products. During discussions with the industrial chemists, the learner discovered that the company was particularly interested in improving the conversion of propan-1-ol into 2,2-dichloropropane and ethyne into phenylmethanol because the products were needed in the manufacture of other products. The company also needed to understand how the reactions for formation of benzene sulphonic acid from benzene and ethanal oxime from ethanal occur. However, the learner was not fully sure about how to do this. The learner has therefore approached you for help.

Task:

As a chemistry learner;

- d) Help the company to analyse the boiling points of their raw materials and products.
- e) Help the learner to provide information on how the above reactions occur and how the products needed by the company can be made.
- f) Evaluate the industrial importance and safety concerns associated with the raw materials in the above industrial processes.

ITEM 29

A cooperative of young entrepreneurs in Uganda plans to establish a small agro-processing and chemical manufacturing enterprise. The enterprise intends to produce and market a range of products, including: a fruit-flavored beverage made from locally grown pineapples and mangoes, a fragrance additive for soaps and cosmetics, a cleaning solvent for industrial and laboratory use and a biofuel additive to improve fuel combustion efficiency.

Before production begins, the entrepreneurs must select suitable organic compounds and production methods. The compounds considered for use are;

- Ethene (C_2H_4)
- Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
- Ethanoic acid (CH_3COOH)
- Propan-1-ol ($\text{C}_3\text{H}_7\text{OH}$)
- Ethyl ethanoate ($\text{CH}_3\text{COOC}_2\text{H}_5$)

During preliminary trials, they observe that some liquids evaporate quickly while others remain liquid for long periods and they wonder why. The cooperative also reacts benzene with concentrated nitric acid and sulfuric acid and propan-1-ol with ethanoic acid in presence of sulphuric acid but lack information of how the reactions actually occur.

They also discovered that several products can be made from the same starting materials and they consider preparing propylbenzoate and propanone each from ethene but lack expertise.

The cooperative also lacks understanding of the suitability of different organic compounds for specific intended applications in production of the different products.

Task

- a) Explain the differences in the evaporation behaviour of the compounds considered for use.
- b) Help the cooperative solve their challenges about the reactions and formation of the intended products.
- c) Assess the suitability of one of the compounds for use in the production of a specified product the company intends to make.

Item 30

The Osukulu infrastructure project in Tororo is designing a modern metallurgical processing plant. The facility is split into two major industrial units.

1. The pyrometallurgical blast furnance unit: needs a heavy-duty internal refractory lining capable of structurally with standing temperatures above 1500°C. The engineering panel choosing between solid sodium fluoride (NaF) and solid Alumina (AL₂O₃) The electrolytic metal extraction unit extracts pure structural metals from molten chemical feeds using low-voltage, high-amperage continuous electrical currents.

As a senior project chemical engineering, you must verify the structural integrity of these compound using thermodynamic cycles and predict extraction outputs using electrochemical principles. Technical data sheet Table 1: thermodynamic values.

Thermodynamic Parameter	Values (KJmol ⁻¹)
Enthalpy of sublimation of sodium	+108
First ionization Energy of sodium	+496
Standard enthalpy of formation of Alumina	-1676
Bond dissociation energy of fluorine gas	+158
First electron affinity of fluorine.	-328
Enthalpy of solution of sodium fluoride	+1
Enthalpy of solution of Alumina	-415
Standard hydration enthalpy of Okide ions	-1420
Lattice energy of sodium fluoride	-924
Standard hydration Enthalpy of Aluminium ions	-4665

Table 2. electrolytic production logs

Constant operating current (I)= 250.0A

Shift production window (t): 5hours, 21Minutes and 40 Seconds.

Faraday’s constant (F): 96500C mol⁻¹

Molar masses: Al= 27gmol⁻¹, Na= 23 gmol⁻¹

Task

As a senior Six, Candidate, the production team at Osukuru infrastructure project.

(a) Construct thermochemical cycles and aid the team interpret the thermodynamic data fully for better and efficient production (including enthalpy of formation of NaF, enthalpy of hydration of NaF of its gaseous ions and lattice energy of $\text{Al}_2\text{O}_3(\text{s})$, $\text{Al}_2\text{O}_3(\text{s})$ defining it as the endothermic energy needed to break the lattice.

(b) By comparing your calculated lattice energies, for NaF and Al_2O_3 , select which material is the best choice for lining the blast furnace wall? Justify your response thoroughly using the concepts of ionic charge, ionic radius and thermal stability.

(c)(i) Deduce redox-reaction occurring at cathode when molten Alumina dissolved in an appropriate solvent undergoes electrolysis and hence use it to determine the total quantity of electric charge (Q) in coulombs passed through the extraction cells during the shift.

(ii) Calculate the total mass in kilograms of pure aluminium metal

deposited at the cathode over this operation window'

Item 31

Textile dyeing needs exact PH levels for even colour bonding, cotton and other cellulosic fibres dye best in alkaline conditions at PH 10.5 to 11.5.

Synthetic fibres like polyester need acidic conditions at PH 4.5 to 5.5. These PH ranges are critical for activating dyes so that they form covalent bonds with the fibre molecules.

The industrial chemist proposed two buffers A and B.

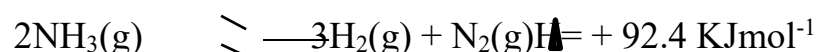
System A: Employ the ammonia solution /ammonium chloride, $\text{NH}_3/\text{NH}_4\text{Cl}$, buffer system, ($\text{PK}_\text{b} = 4.76$, $K_\text{w} = 1.0 \times 10^{-14}$) to achieve the optimum alkaline conditions. This is achieved by preparing 0.1M ammonia solution and 1.2g of ammonium chloride to make one litre of the mixture.

System B: Using ethanoic acid/sodium ethanoate,

$(\text{CH}_3\text{COOH})/(\text{CH}_3\text{COONa})$, buffer system, ($\text{PK}_\text{a} = 4.18$) to achieve the optimum alkaline conditions. This is prepared by dissolving 0.1M ethanoic acid to 8.2g. Sodium ethanoate to make one litre of the mixture for optimum acidic conditions.

He seeks to determine the PH values of A and B and to ascertain the operational mechanism system A.

To meet high cotton demand, the company plans to produce ammonia for nitrate fertilizers used on cotton plantations. To test product composition, the chemist heated 1.5 moles of ammonia in a 1-litre reactor. At equilibrium, the mixture contained 52% hydrogen. The equilibrium below took place.



The management of the company wants to address the concerns. The fertilizer plant's industrial chemist aimed to find the equilibrium constant K_c and assess how higher temperatures affect the equilibrium. This is to keep the produced ammonia stable because poor control of equilibrium can lower yields and raise production costs.

He has approached you for some guidance.

Task :

As a learner of advanced level chemistry class, prepare a presentation to address all the chemists queries and also propose suitable optimization mechanisms so as to maintain a continued production of Ammonia in the industrial.

Item 32

Roofing's limited is one of Uganda's top steel manufacturing companies. To enhance purification process, management plans to choose a component that can act as a chemical scavenger. The ideal material would capture impurities and

naturally rise to the surface of the molten steel, allowing both the component and the trapped impurities to be skimmed off. Some group 2 elements have been identified for the exercise. The following data has been availed to the management by one of the industrial trainees.

Element	Be	Mg	Ca
Metallic radius (pm)	112	160	197
Density (gcm ⁻³)	1.85	1.74	1.55

The management wants to know how the data provided can be used to select the component. The assistant production manager is interested in knowing the behavior of the identified components each with air, moisture and with acidic solution.

You have been contacted for guidance.

Task

As a learner of chemistry, prepare a presentation on issues at hand. The investigation should additionally cover health hazards related to the identified component and explore other areas where it can be applied.

Item 30

Management at an electronics factory in Namanve industrial area has received customer complaints that the CPU – processors in their New DELL-P laptop model frequently fail because they cannot withstand the high temperatures generated during demand tasks such as live streaming and gaming.

The brand manager is considering replacing the current component in these processors with sodium, aluminium or silicon. However, selecting the most suitable option remains a challenge.

To support the decision-making process, he has sourced relevant data on these elements from the internet.

Element	Na	Al	Si
Melting point (°C)	9.8	660	1410
Electro positivity values	1.08	0.62	0.53

Table one; showing data downloaded online.

The brand manager seeks to determine the relevance of the collected data in their project. He further requires information on how these elements can respond if exposed to water, diluted acid solutions and alkalis. Beyond assessing the daily – life utility of the selected component, he also wishes to evaluate any environmental hazards associated with the selected component.

He has consulted your chemistry teacher for assistance in preparing a presentation for the upcoming meeting.

Task

Using the knowledge of chemistry, you have attained, prepare a presentation to guide the manager.

Item 33

In an agricultural industry in Mukono, liquomax and Tos-B are added to a herbicide as a solvent and fragrance respectively.

A women’s group in the same locality is planning to set-up a project to produce their herbicide to cheaper costs.

Mrs. Opoka, a chemistry teacher who is one of the members in the group has suggested some materials for the solvent and fragrance as propene and benzoyl chloride respectively.

However, some members have raised concerns on unreacted residues from the raw materials as these may have potential health risks. In response, Mrs. Opoka has suggested to react these residues in the fragrance and solvent manufactured with hot concentrated ammonia solution and hot alcoholic potassium hydroxide solution respectively as a mitigation strategy.

In order to maintain the production series, she has advised the team to use the available ethanol in stores to obtain the raw materials.

The project manager has come for some guidance on Mrs. Opoka's advice about the project.

Task

As a learner of chemistry.

(a) Guide the manager on how.

- (i) The raw materials selected are suitable for the role.
- (ii) The reactions for mitigation strategy occur.
- (iii) The production series can be maintained.

(b) Explain any other uses of the residues in the fragrance and health hazards associated with their continued use.

Item 34

A group of senior six learners intend to make a presentation in a science fair on a compound Q with molecular formula of $C_5H_{12}O$ that was provided by the organizers. Q and ethanal are the selected components thought of to be used as a solvent in a certain cosmetic brand. However, the management has not yet decided on one.

Knowing all the structures and names of all possible isomers of Q, its identity was their first priority.

Preliminary tests involved treating samples of Q with anhydrous zinc chloride in presence of concentrated hydrochloric acid and a cloudy solution was formed after 8 minutes.

The organizers had provided small samples of Q and ethanal respectively as the raw materials from available stock of bromoethane.

However, their worry was on what can be done on the residual unreacted raw materials as these may have environment concerns. One of the members suggested to react Q and ethanal with hot concentrated sulphuric acid and with 2,4-dinitrophenylhydrazine solution respectively as the safety control measure.

You have been selected to be part of the team.

Task

As a learner of chemistry, prepare a write up you will present in the plenary on meeting the team. In your presentation; (a)(i) Present the structures, names of the isomers and hence its identity.

(ii) Explain why the compounds selected are each suitable for their role.

(b) Guide them on how reactions will occur during safety control measures.

(c) Guide them on how more raw materials can be obtained from a compound that is available.

(d) Explain any other use of the selected raw materials and environmental hazards talked of.

ITEM 35

A metal and ceramic manufacturing industry in Namavne in Mukono district in Uganda is planning to construct modern high-temperature resistant coating furnaces for steel extraction and processing in other districts in Uganda. The technical team is evaluating the use of aluminium oxide and sodium fluoride in ceramics and furnace linings. They also need to evaluate and select the suitable cooling and stabilizing agent in the chemical preparation units and the most suitable element for manufacturing yellow security lights. There was guidance that the heat of solution, formation from elements, ions, and sublimation can be used, although it was not clear. The research team has sourced aluminium from scrap recycling, sodium and fluorine from Lake Katwe in Kasese, and oxygen gas from Uganda Oxygen Ltd. On analysis, the following thermochemical data were obtained.

Type of reaction	Energy (kJ mol ⁻¹)	Type of reaction	Energy (kJ mol ⁻¹)
Sublimation of Al	+330	Sublimation of Na	+109
First ionization energy of Al	+578	First ionization energy of Na	+494
Second ionization energy of Al ⁺	+1820	Atomization of F ₂	+158
Third ionization energy of Al ²⁺	+2750	Electron affinity of the F atom	-328
Atomization of oxygen O	+249	Formation of NaF from elements	-589
First electron affinity of oxygen, O	-142	Hydration of Na ⁺	-406
Second electron affinity of oxygen O	+793	Hydration of F ⁻	-505
Formation of Al ₂ O ₃ from its ions	-15,346.5		

One group employee in charge of cleaning wishes to know from the research team the quantity of aluminium that can be recovered from

1200kg of metal scrap. The team provided information that it can be done by allowing a current of 2 amperes to pass through molten scrap for an hour, and additional data below was given, which they said would be of help. $1F = 96500C$, Molar mass of Aluminium = 27 .

Task:

As a knowledgeable learner of chemistry, help to;

- address the concerns.
- understand what would happen to mass of metal recovered when time and current are adjusted.

ITEM 36

During a class visit to a food-processing and storage company in one of the towns in Uganda, learners were told that salt is added to ice when preserving fish and meat during transportation. The company scientist explained that the

concept of adding salt to ice lowers the freezing point, making the mixture colder than pure ice. This helps keep food fresh for longer, though it has environmental implications when the wastewater is discharged into a nearby water body. He said the environmental standards require that the waste salt concentration should not exceed 0.5 g per 1000g of water, which is done by treating the wastewater with 0.1M lead (II) nitrate solution. On returning to school, the teacher gave them a table of empirical data to support the idea, and it was used as a follow-up in an assignment.

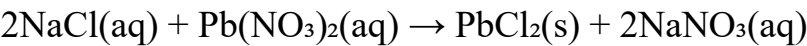
The figure below is a table of the data provided.

Mass of NaCl added (g)	Freezing point (°C)	Change in freezing point $\Delta T_f \times 10^1$ (°C) ⁻
0.0	0.0	0.0
2.0	-1.2	1.2
4.0	-2.3	2.3
6.0	-3.5	3.5
8.0	-4.6	4.6
10.0	-5.8	5.8

- Molar mass of NaCl = 58.5 g
- Mass of solvent = 1000 g
- Freezing point constant 1.8 °C / 1000g of solvent

After analyzing a sample of wastewater that had been carried to school by the teacher, he further gave the following additional information:

10.0cm³ of water sample needed 22.5cm³ of the nitrate solution that reacts as in the equation:



The information provided could not be used without your assistance as a knowledgeable person.
Task.

Prepare a written document to help them to;

- a) Understand the concept of the scientist.
- b) (i) Comment on the graphical freezing point constant.
(ii) Evaluate the level of pollution.
- c) Analyse applications of the concept.

Group 14 elements include carbon, silicon, germanium, tin, and lead. Many of their compounds are widely used in everyday life, e.g., beverage manufacture, construction, and electronics, etc. After studying Group 14 (IV) elements of the Periodic Table, a group of Advanced Level students carried out a research activity to investigate the properties of the oxides of these elements in the +4 oxidation state. The information they collected was intended for use in a class presentation in the following lesson. During their research, they obtained the data below:

Oxide of an element	Melting point (°C)	Physical state
Carbon	-56	Gas
Silicon	1710	Solid
Germanium	1115	Solid
Lead	290	Solid

However, the students were unable to interpret the data because they did not understand the difference in physical state of the oxides, melting points, the interactions of the oxides with hydrochloric acid and sodium hydroxide, and the industrial use of the oxides of carbon, silicon, and lead, together with their health implications.

They therefore approached you for assistance, believing that you could help.

ITEM 38

Material selection is important in construction engineering. A small-scale project group near your school wanted construction of its walls to withstand high temperatures, and other environmental conditions like water and acids. The project team is exploring some oxides to determine the most suitable as a component for construction. The team researched and obtained the following from the data bank about the oxides

The team lacks enough knowledge and has contacted your school for guidance about the choice of oxide, its other uses, and health impacts.

Oxide of an element	Na	Mg	Al	Si
Melting point (°C)	1548	3100	2290	1880

ITEM 37

Alcohols are important raw materials in the production of sanitizers, which can serve as a viable source of income. A school science club plans to manufacture an alcohol-based sanitizer and a perfume; however, members are uncertain whether to use propan-2-ol or methylpropan-2-ol. The effectiveness of alcohol-based sanitizers depends on their ability to penetrate disease-causing microorganisms, denature their proteins, and on the perfume’s slow diffusion, a property influenced by the structure and type of the alcohol used.

The club members have been tasked with selecting the most appropriate alcohol for this purpose. Unfortunately, neither of the preferred alcohols is available in the laboratory. The chemistry teacher has instead advised them to use the available methanol and propanal to synthesize a suitable alcohol for sanitizer and perfume production.

During their discussion, one member raised concerns about the environmental impact of sanitizer disposal. These concerns were addressed by a colleague who proposed dehydration using concentrated sulphuric acid, or turning it into a perfume using vinegar as a way to mitigate environmental effects before discharge. Although the idea was accepted, the concerned member requested a clear explanation of the reactions involved.

The group has now approached you for guidance.

Task: a) Evaluate the criteria for selecting a suitable alcohol and how it can be obtained, as advised by the teacher. b) Analyse how the proposed mitigations occur. c) Assess other potential applications and possible health hazards associated with the raw material.

The group has now approached you for guidance.

Task:

- a) Evaluate the criteria for selecting a suitable alcohol and how it can be obtained, as advised by the teacher. b) Analyze how the proposed mitigations occur.
- c) Assess other potential applications and possible health hazards associated with the raw material.

ITEM 39

Sparingly, organic soluble dyes and flavors are usually added to processed foods in the industry. A local food supplement manufacturing unit in the nearby trading center is exploiting the use of two organic food additives for their packaged foods, made from a phenol, and the other from a ketone of three carbon atoms, due to their physical properties. They could not find both raw materials on the market and have been advised to use a readily available and cheap product of fermentation of carbohydrates as feedstock. One of the members in the manufacturing unit stated that they can get their food additives when the phenol reacts with ethanoyl chloride, and the ketone reacts with Brady's reagent in acid medium. However, it was not clear how the reactions occur, and the health implications of the additives when consumed in excess. As the only secondary school near the unit, your chemistry teacher has been consulted for guidance, and the teacher has asked you to do the work as an assignment.

Task:

Make a write-up you will present to the teacher addressing the concerns raised by the unit.

ITEM 40

A manufacturing company specializing in construction materials uses thermal stability as a key factor when choosing raw materials. An industrial chemist advised that aluminium oxide, Al₂O₃, could be a suitable raw material despite the fact that it is amphoteric and reacts with both acids and bases. In a parallel view, an environmental chemist, after noticing a high level of concentration of aluminium ions in water discharged by the company, advised that before discharge aluminium metal could be recovered from solution using metal Q and provided the following thermochemical and electrochemical data. Thermochemical data provided;

Standard enthalpy of formation of Aluminium Oxide = -1675 kJ mol⁻¹ Standard enthalpy of atomization of Aluminium = +330 kJ mol⁻¹

1st ionization energy of Aluminium = +577 kJ mol⁻¹

2nd ionization energy of Aluminium = +1817 kJ mol⁻¹

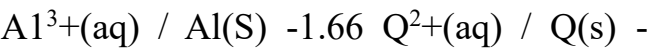
3rd ionization energy of Aluminium = +2745 kJ mol⁻¹

Standard enthalpy of atomization of Oxygen = +249 kJ mol⁻¹

1st electron affinity of Oxygen = -141 kJ mol⁻¹ 2nd electron affinity of Oxygen = +798 kJ mol⁻¹

Electrochemical data provided;

Half-cell



0.76V Task:

- a) Analyse the observations made using the data provided.
- b) Assess how the use of metal Q can optimize the recovery of aluminium ions from the solution and make recommendations, if any.

ITEM 41

Chemical industries producing dyes and pharmaceuticals rely on solvents like naphthalene and precise knowledge of molecular characteristics of additives and impurities. At the same time, the local water supply shows signs of contamination, with an unknown weak acid solute T affecting the freezing point of water in storage tanks. The water treatment facility collected the following data on solute T:

Concentration of T (g/dm ³)	0	30	60	90	120	150
Freezing point Cc)	0	-0.16	-0.32	-0.49	-0.65	-0.81

The Cryoscopic constant for water is 1.86 oc kg mol⁻¹.

After identifying T, the company decided to reuse it. T is a weak monobasic acid HT. To make a disinfectant solution for equipment cleaning, the technician must prepare a sample solution whose pH change should be less than 5.0, because bacteria don't thrive well in that range.

The technician mixes sodium hydroxide with the purified acid HT to form its salt NaT, but is confused why the solution does not appear neutral. He has tasked you with rigorous analysis to ensure the disinfectant is safe and effective.

Technical Data:

Ka for HT= 1.8 x 10⁻⁵ mol dm⁻³ and 1.0 x 10⁻¹⁴ moldm⁻⁶ at 250C Batch 1: Created by mixing 50cm³ of 0.05M HT with 50cm³ of 0.02M NaOH solution. Batch 2: Created by mixing 50cm³ of 0.02M HT with 20cm³ of 0.05M NaOH solution.

Task:

- a)Assess the company's concerns on solute T used
- b)Evaluate the technician's disinfectant batches and comment on their effectiveness and safety uses.

Respond to any one item in this part

ITEM 42

Aero space construction company are in the process of selection of the materials based on their durability once put into use. A class of senior five students are exploring the materials that make aero plane body and engines.

The information they got, shows that the materials needed for use are aluminium and iron, and their selection for use depends on their structural properties, how they interact with environmental conditions and their health/environmental side effect(s). Additional information shows that the engine propellers made of iron can be coated with magnesium but not the engine blocks while the aero plane body can be constructed with beryllium instead of aluminium due to their similar properties. These students failed to understand the information they obtained and they have been referred to you for help. Task:

- Assess the properties of the materials and comment with reason which of these materials would best for selection in the aerospace construction.
- Analyze the interactions of the materials with the environment and help the learners understand the information on preference of the materials in different parts of the aero plane.
- Assess the impacts of using these materials to the environment.

ITEM 43

A chemical plant near Lake Victoria is exploring Group 17 elements and their compounds to treat drinking water for a nearby community. In order to access safe water, the structural properties such as atomic radii and boiling points of the elements, they intend to focus on so as they can balance their effectiveness and safety for workers as well as the environment.

Your chemistry class intends to visit this plant to explore more about these elements, their compounds and practical applications in daily life. To achieve the study purpose, your chemistry teacher has given you the following guiding questions which will be used during the study time in the plant.

- Between chlorine and iodine which one would be suitable for water treatment and why?
- Why would dumping of industrial wastes containing hydrofluoric acid into the water is considered less harmful compared to hydroiodic acid.
- Why concentrated sodium hydroxide is used to trap fumes containing chlorine gas produced in the production process.

Your subject teacher wants you to assess and evaluate about these elements and their compounds by making detailed report that will be presented to the headteacher of your school.

Element	F	Cl	Br	I
Atomic radius (nm)	0.072	0.099	0.114	0.133
Boiling point/ ^o C	-188	-34	+58	+185

The site safety quality officer, responded to those questions that the gaseous fume should be treated using strong alkalis to prevent its emission in the atmosphere. And the liquid industrial wastes containing the strong hydride can be treated with calcium oxide before disposal. Task: a. Analyze the observations you obtained during the study at the plant.

- Justify the responses given by the tour guide.
- Assess the impacts of using these products to the environment.

ITEM 44

Use of perfumed deodorants is growing fast in Uganda. Abacus pharmaceutical Company plans to start production. The company chemist reported two production routes:

Chloroethane is obtained from compound X, straight chain hydrocarbon with 2 carbon atoms that is used to make compound Y, methyl ethanoate serving as fragrance.

Compound X is used as a feedstock to make organic compound W an alcohol with 3 carbon atoms that produces propanoic acid needed for deodorant action. For proper waste control, the company analyst suggested reacting any leftover of chloroethane with benzene and any leftover of compound X with liquid bromine with a suitable organic solvent. The company's management is interested in the suitability of the products, their applications, and synthesis pathways for the products, with lasting mitigation reactions for the unreacted raw materials and the associated environmental impact of the application of its product.

Task:

- a. Examine the compounds provided to help the company determine the production of the most suitable active organic ingredients,
- b. Analyze the reaction mechanisms and processes involved in the formation of organic products from any leftover chloroethane, with benzene, compound X and bromine.
- c. Evaluate the practical applications of the various organic products intended to be produced by the plant including any side effects of the products.

ITEM 45:

The use of polymers and solvents in grease production is growing rapidly in Uganda. A manufacturing company uses propene to make polystyrene, and propanol as a solvent for grease.

As their daily routine mitigation measures, the company runs two parallel

reactions: 1. Propene with bromine water.

2. Ethanol with concentrated Sulphuric acid at 180°C to form a hydrocarbon R.
3. The compound R serves as feedstocks for making benzene, a six-carbon hydrocarbon and phenylethane, an aromatic hydrocarbon with 8 carbon atoms and molar mass of 104.

Additional information from the company, shows that they always conduct impact assessment of their polymer raw materials with appropriate mitigation measures before availing them in the market for use. Task:

- a. Examine the compounds provided to the plant, to help the team determine the most suitable for making plastic materials and solvents.
- b. Analyze the reaction mechanisms including the processes involved in the formation of propene and bromine water, ethanol to hydrocarbon R, benzene to phenylethane.
- c. Evaluate the impact(s) of the product(s) intended to be produced.

ITEM 46

Most Ugandans depend on second hand shoes mainly from Turkey, China, and India. However, due to improved income through different government initiatives such as Boona Bagagawale, PDM and loan schemes for agriculture ventures. Many Ugandans are opting to using first hand shoes. Unfortunately, this seems to remain as a dream due to high costs involved in their importation. Mr. Opio a wealthy man in Hoima picked interest in starting a shoe factory. Through his

research, he noticed that the cheapest way is using a raw material from rubber trees which mainly contains **2-methylbuta-1,3-diene** to make shoe soles. However, the material required needs some improvement to make it more suitable for its use. Or alternatively use a laboratory made material (synthetic rubber) mainly obtained from. (**2-chlorobutane-2,3-diol**). However, if the synthetic raw material is used, the un unused portion is reacted with Hydrogen gas in presence of nickel catalyst to form **compound Q**, which is reacted with hot alcoholic potassium hydroxide to form **compound R** that is converted to methylbenzene a very important organic solvent.

Unfortunately, this process leaves many unwanted organic compounds such butan-1-ol and 2-chloro butane. As a mitigation measure, the production system is treated with sodium hydroxide and excess concentrated sulphuric acid and the single gaseous product formed is condensed and packed in cylinders to minimize the environmental impacts of the pollutants. Mr. Opio would love to know the process of improving the properties of natural rubber, the reaction pathways through which the synthetic rubber and methylbenzene are obtained, the reaction mechanisms for formation of R and the mitigation measures and environmental implications of one of the products formed along.

Task:

As a student with knowledge of chemistry, prepare a write up to help Mr. Opio analyze the details he read.

ITEM 47

Royal Techno Projects (Africa) Ltd in Jinja, produces a variety of organic materials used in plastics, fuels, solvents and disinfectants. The company mainly uses hydrocarbons and as a route the compound to be used is first investigated/analyzed. In one of their experiments, 20.0cm^3 of a gaseous hydrocarbon Q was exploded with 150cm^3 of excess oxygen. After complete combustion, the remaining gas volume was 110cm^3 . When this residual gas was treated with concentrated potassium hydroxide solution, the volume decreased further to 30cm^3 . The company obtained the molecular formulae of Q as C_4H_8 also observed that ozonolysis of hydrocarbon Q produced similar compound and it rapidly decolorized bromine water. The company bases on these reactions to choose the best product. The current industrial uses of Q at the company are to obtain propan-1-ol, Benzoic acid, 1,2-dibromopentane and 1-chlorobutane. Despite all the available and documented reports at the company, some workers need more information about the compound used, how it is chosen how the products are produced from it and its environmental impacts.

TASK

As a chemistry student, prepare a detailed presentation that addresses all the points above for the company.

ITEM 48

Organic chemistry and its applications is the basis of chemical revolution in the world, Uganda inclusively with the main goal of Organic chemical transformations using renewable raw materials such as bioethanol obtained from plant materials. One of the simple molecular transformations is obtaining ethene from bioethanol and converting it to benzene an important non polar solvent. However, obtaining methylbenzene is a better alternative basing on their reactivity differences. Ethene is also an important monomer in the preparation of the commonly use packaging material.

However much the organic molecules are very important, they have greatly threatened human life and the environment.

The main concerns due such transformations are; comparing the difference in reactivity of benzene and methylbenzene and the packaging material, obtaining methylbenzene and the packaging material from the identified compounds, Examining the reaction that produces ethene.

And explaining why organic chemical wastes, especially waste containing methylbenzene must be properly disposed and how it is achieved.

Task:

Write a detailed guide report to address the concerns above.

ITEM 49

Not only dressing to kill, the Ugandan youth, the Genz have greatly copied the living styles of Americans by over depending on perfumes. A pharmaceutical company in Uganda has realized this demand. However, exporting already made products from south Africa and D.R Congo seems expensive. One of the team members got an idea of using bananas to obtain the basic raw material, from which a number of products can be obtained such as ethyl ethanoate, ethene and nitrobenzene which is a key compound in the manufacture of Azo dyes with other compounds such as phenol. To cut expenditure costs, the member also suggested that the unused basic raw material could be reacted with concentrated sulphuric acid at 140°C to obtain an ether that could be sold to Automotive company to be used as an Engine starting fluid.

However, most of the members are concerned about the suitability of the main product to be used in the perfume production, how the raw material is obtained, reaction pathways to nitrobenzene from the raw material, reaction and mechanism leading to production of ethyl ethanoate and the ether and environmental impacts of any product. **Task**

Write a report to address the concerns of the members.

ITEM 50

Most petrol stations in Uganda were advised by ministry of energy to use petroleum products that contain an organic compound (C₄H₁₀) whose composition ratio is 4.8:1 carbon and hydrogen respectively. However further analysis of organic compound show that it occurs in two isomeric forms. This has caused confusion in the market. To solve this issue, the petroleum industrialists gave some guidelines. i) The organic compound should be highly volatile with lower boiling point.

ii) It should have a lower density.

However the drivers and some petrol station workers are still skeptical and need more information. Some written literature about the organic compound show that it can be obtained from propene or 3-methylbutanenitrile. The company also plans to use a product obtained from the reaction of the best isomer with chlorine as gasoline additive. It is also suggested that the best product can be obtained from 2-chloropropane.

The main concerns are choosing the best isomer to use basing on the properties provided, explaining the reaction mechanism leading to formation of the gasoline additive, describing the reaction pathways of obtaining the best isomer from 2-chloropropane and explaining the environmental impacts of the fuels.

Task:

Write a report to address the concerns of the members.

ITEM 51

Recently Uganda has embraced the use of biogas to minimize deforestation. However, during its preparation traces of sodium propenoate and chloroethane are obtained. As a mitigation measure, the traces are converted to less harmful chemical compounds such as butane, ethane and Nitro benzene. However, most of the products still pose environmental impacts. To curb this, the biogas production company was sodium hydroxide and concentrated sulphuric acid to obtain product

Q that is delivered to Hima cement from where it is converted to a packaging material.

Task:

- Explain the suitability of the main compound of biogas to its intended use.
- Analyze and explain how the mitigation measures help to prevent accumulation of the pollutants produced along biogas.
- Examine the chemical reactions that occur to the named pollutant up to production of the packaging material.
- Explain the impacts of over dependence on bio gas.

ITEM 52

Petroleum and coal are on a high demand in Uganda. However, their pyrolysis produces a mixture of hydrocarbons. An organic compound with molecular formula C_6H_6 takes the highest percentage in the mixture. However, having limited uses undergoes series of chemical reactions to form nylon-6,6- and azo dye. The nylon material is used to make all bags, yoga pants and gym clothes. However, continuous use of the product obtained from organic compound has caused a great environmental impact. As one of the mitigation measures, the organic compound is reacted with Nitric acid, sulphuric acid and propene to minimize its accumulation.

Task:

- Explain the properties that make one of the products obtained from the organic compound suitable for its intended uses.
- Carefully analyze the organic compound and design reaction pathways to obtain the intended products.
- Examine and explain the mitigation measures.
- Explain the environmental impacts of the organic compound.

ITEM 53

In a peri-urban district near Kampala, a cooperative of local entrepreneurs produces bioethanol from cassava and sugarcane to supply fuel, sanitizers, and small-scale pharmaceutical industries. Alongside this, a nearby resin-manufacturing workshop uses phenol-based compounds to produce adhesives and insulating materials.

Recently, two major concerns have emerged:

- Cases of skin irritation and respiratory issues among workers handling phenolic resins.

☐ Reports of adulterated alcohol products in the local market, causing health risks due to improper purification and contamination.

The cooperative produces the following compounds:

Compound Approximate boiling point

ETHANOL	78°C
PROPAN-2-OL	82.5°C
PHENOL	181.7°C

The district environmental and health office has engaged your school's chemistry club to investigate the chemical nature, properties, and safe use of alcohols and phenols, and to propose sustainable solutions.

Tasks

ITEM 54

In a rapidly industrializing district near Lake Victoria, a small-scale chemical plant has been established to produce solvents and intermediates for local manufacturing industries such as paints, plastics, and pharmaceuticals. Among the key products are alkyl halides (haloalkanes), synthesized from locally available alcohols.

Recently, environmental officers and public health experts have raised concerns about increased air and water pollution around the plant. Reports suggest that improper handling and disposal of alkyl halides particularly chlorinated and brominated compounds may be contributing to ecological toxicity and potential human health risks. At the same time, the factory management argues that these compounds are essential for economic development, as they serve as precursors in important industrial reactions such as polymer production and drug synthesis.

The plant produces three alkyl halides:

- ☐ 1-chlorobutane
- ☐ 2-bromobutane
- ☐ 2-bromo-2-methylpropane

As a chemistry student attached to a community science initiative, you are tasked with investigating both the chemical behavior and the societal implications of alkyl halides used in the plant.

Tasks

(a) (i) Analyze how the structure of each compound influences its reactivity with:

- ☐ Aqueous sodium hydroxide
- ☐ Alcoholic potassium hydroxide

(ii) For each reaction, identify whether it proceeds via:

- ☐ Nucleophilic substitution (SN1 or SN2)
- ☐ Elimination (E1 or E2)

(b)(i) Predict the major organic products formed and outline the acceptable mechanism when:

- ☐ The secondary alkyl halide reacts with hot alcoholic potassium hydroxide

- 7 Tertiary alkyl halide reacts with hot aqueous sodium hydroxide(ii) Using equations, show how the secondary alkyl halide can be converted to butanone via an alkyne
- (c) Evaluate the uses of alkyl halides in the local plant
- (d) Assess the negative impacts associated with alkyl halides(e) Propose practical solutions to reduce the harmful effects of alkyl halides in the community.

ITEM 55 50

The demand for N-phenylethanamide, a precursor for manufacture of drugs in Uganda, has increased of recent. A pharmaceutical company makes N-phenylethanamide from benzene and a perfume methyl propanoate ($\text{CH}_3\text{CH}_2\text{COOCH}_3$) from bromoethane. The unreacted benzene is mitigated by reacting it with ethanoyl chloride in the presence of a halogen carrier and propanone with hydrazine (NH_2NH_2) in acid media.

The pharmaceutical company is interested in the suitability of N-phenylethanamide to its application, synthetic pathways for its products, mitigation reactions for unreacted raw materials and environmental implications of one of its products.

Task: As a learner of chemistry analyse and interpret the available data to address the company's issues.

Item56 11

Use of polymers for carrier bags is of high demand in Uganda. A manufacturing company has been advised by an industrial chemist to produce polythene from propan-1-ol and mitigate the effects of unreacted raw material using concentrated sulphuric acid at 140°C . In another parallel synthetic route, the company makes ethanol for distilling sanitiser from propanone and mitigates the effects of the unreacted raw material using hydrazine (NH_2NH_2) in acid media.

The company's management needs information on the suitability of polythene for its applications, synthetic pathways for its products, mitigation reactions for the unreacted raw materials and an assessment of environmental implications of polythene. Your teacher came across this information.

Task: As a student of chemistry, your teacher has requested you to make an analysis and interpretation of the information provided to address the company's concerns.

ITEM 57 12

A certain town in central Uganda faces growing concerns over water pollution from agroprocessing industries, especially during the cocoa harvest season. Wastewater from cocoa processing plants often contains organic matter including acids, and amines that can harm aquatic life if released untreated.

A group of entrepreneurs is setting up a small plant to process cocoa husks, a by-product of cocoa bean production, into value-added products. Chemical analysis of the husks shows that they contain ethanol (from natural fermentation), ethanoic acid, small amounts of amines (from protein breakdown), and aromatic aldehydes such as vanillin(4-hydroxy-3methoxybenzaldehyde).

To address the water pollution challenge and create additional revenue streams, the team plans to:

1. Determine the relationship between the structure of vanillin and ethanoic acid, and their solubility.
2. Convert ethanol into amines for use in water treatment and cosmetics.
3. React ethanoic acid with ethanol to produce an ester for fragrances, and study its reaction mechanism.
4. Evaluate the use of the esters and amines in producing fragrances and cosmetics.

Task

You have been tasked by your teacher to design feasible chemical processes, explain the underlying organic chemistry, and propose sustainable solutions to help the plant reduce environmental harm while maintaining profitability.

Item58

Use of dyes in manufacturing industries and alcohol-based sanitisers in daily life is increasing in Uganda. A manufacturing company uses benzene and N,N-dimethylaminobenzene as raw materials in its dye production chain and bromoethane as a raw material in the manufacture of propanol for the alcohol-based sanitiser chain.

As a mitigation measure, management noted that unreacted benzene is reacted with propene and the unreacted bromoethane is reacted with aminoethane. The company's management is interested in the suitability of its products to their applications, synthetic pathways for its products, and mitigation methods for its operations. It has approached you for help.

Task: As learners of chemistry, help the company's management to address its concerns and the associated environmental implications of the application of its products.

Item59

Use of polymers and solvents for grease is becoming of high demand in Uganda. A manufacturing company uses propene to manufacture polythene and propanol to prepare a solvent for grease.

In a parallel chain reaction as a mitigation measure, the company reacts propene with bromine water and propanol with concentrated sulphuric acid at 180°C.

The technical team of the company wants to know the suitability of its raw materials for its operations, synthetic pathways for its products, mitigation reactions, and an evaluation of the environmental impacts of the application of its products.

Task: As a student with knowledge of Chemistry, prepare a write up to help the technical team of the company.

ITEM 60

15

Organic compounds are important material used in manufacture of some of items used by community.

A group of senior five students decided to use propanone available in the laboratory as a raw material to produce some useful product for use in the school. They contacted the chemistry teacher who suggested that they should use the raw material to produce propanone oxime an important material in agrochemical sector. The teacher also suggested that in case they remained with some propanone un used they can convert it to 2-methyl propanoic acid which is less volatile and can be used to manufacture perfumes. He further suggested that they can use some of the propanone to produce 3-phenyl propan-1-ol a compound used to preserve some organic solvents. In addition, he said they can reduce propanone

in order to form compound Q which they can dehydrate to form another product R. The students failed to understand well the teacher's guidance and therefore requested for a write up for detailed understanding. For better understanding the students should have knowledge of writing equations using arrows to show how propanone oxime is formed from the raw material and how compound R is formed from Q. In addition, the students should have knowledge of writing equations for reaction pathways showing how 2-methyl propanoic acid and 3-phenyl propan-1-ol are formed from the raw material. The students should also have knowledge on physical properties of perfumes in relation to its formation and its application.

Task

Write a report to give guidance to the students.

ITEM 61

16

Organic compounds are essential materials used to produce variety of products used in society.

A group of entrepreneurs from a community ventured into a project of using benzene as a raw material to prepare solvents for pesticides. They contacted the laboratory technician for guidance. The laboratory technician suggested their choice should be cyclohexanone. He said this can be achieved by reacting benzene with chlorine in presence of halogen carrier in order to form a product M and then proceed. He also suggested that they also react the raw material with sulphuric acid to form product N which acts as an intermediate compound in manufacture of detergents. He also proposed that in case there is excess of the raw material they can mitigate it by reacting it with nitric acid as one of the reagents to form an intermediate compound Q that can be used to prepare phenol which is used as an antiseptic. The entrepreneurs failed to clearly understanding the guidance and requested for a write up for better understanding. For effective implementation of the project the entrepreneurs should have knowledge of writing equations using arrows to show how compounds M and Q are formed from the raw material. In addition, they should also have knowledge of writing equations for the reaction pathways leading to the formation of antiseptic and the solvent for pesticides from the raw material. They should also have knowledge on physical properties of solvent for the pesticide in relation to its formation and its application. The entrepreneurs failed to get clear understanding of the process. The laboratory technician has identified you as a learner with sufficient knowledge and asked you to write a report for guidance.

Task

Write a report that you will use to guide the entrepreneurs.

ITEM 62

A small chemical plant near a rural community recently discharged an unknown hydrocarbon into a drainage channel used by households and livestock. Environmental officers collected the sample, labelled G, and performed preliminary tests. The molecular formula of G is C_4H_6 , and when treated with silver nitrate solution in ammonia, a white precipitate was formed. Further tests with bromine water and acidified potassium manganate(VII) indicate that G contains unsaturation. The environmental chemistry team is tasked with identifying G and investigating its chemical properties. They also need to predict its likely reactions in both laboratory and environmental conditions, explore possible synthetic routes from simple alkenes such as but-1-ene, ethanol and a metal residue calcium carbide, and assess potential environmental and health impacts. The team is particularly interested in the mechanism of how G reacts with water in the presence of sulphuric acid and mercury(II) sulfate, with hydrogen bromide to yield 1-bromo compound, bromine liquid and potassium manganate(VII) using equations. Safe handling and mitigation strategies are also to be considered.

The team also is interested in the pathway of conversion of G into certain aromatic compounds such as Toluene(methylbenzene), benzaldehyde, and Phenylalanine(Aniline) which can be converted to certain salicylates such as aspirin (4-hydroxybenzoic) Before any decision is made the team must know: structure, functional group and possible isomerism of compound. Apply correct IUPAC names to G and all related products formed in laboratory reactions. Predict major products at each reaction stage based on organic reactivity and mechanism for key reactions. Explain stepwise reaction pathways leading formation of G, classifying type of reaction at each stage, and evaluate the environmental and health impacts associated with G and its derivatives while proposing mitigation strategies.

Task:

As a learner of chemistry, make a write up to help the team inform their decision making.

ITEM 63

Napak Quality Chemical Industries Ltd; a pharmaceutical manufacturer, is currently working on expanding the production of local Active Pharmaceutical Ingredients (APIs) used in anti-infectives, analgesics, and sedatives. To reduce dependence on imported raw materials, the company has started a project to localize the synthesis of certain organic intermediates used in: Analgesic and antipyretic drugs and Solvent and extraction systems used during API purification. During process development, the research and development team identified two key building blocks, 1-bromobutane and 2-bromobutane used as alkylating agents in side-chain construction. The company currently has only two raw materials available for the project, Ethene and propan-1-ol. However, the production team is stranded and uncertain about, the best building block material to be used industrial processes (the best building block must have a higher boiling point), the reaction pathways to obtain the best building block from the available raw materials and appropriate conditions needed for the reactions to occur and mechanisms of reaction, of the best building blocks with alcoholic potassium hydroxide, and aqueous sodium hydroxide solution and the associated environmental and health impacts of using and disposing of alkyl bromides in a pharmaceutical industry. Because of this uncertainty, the manager has contacted you, to provide scientific guidance so production can begin.

Task

Write a clear report to guide the manager.

INORGANIC CHEMISTRY

Item 64

Students of Mandera High school visited Abacus Parental drugs Limited in Mukono to study the suitability of solvents in drug production. The tour guide (Pharmaceutical scientist) told them organic pigments obtained from plants are dissolved in suitable solvents. Some pigments are dissolved in solvents which are stored at high temperatures (about 50°C). He added, some pigments are obtained with water adsorbed on their surfaces. Out of curiosity, a student asked if chlorides of carbon, silicon and tin in +4 oxidation state could be considered as solvents for the organic pigments. The guide responded saying one of the substances which the learner had mentioned was unsuitable. However, its oxide is industrially useful and has a limitation in its application that should be mitigated.

As a chemistry learner

a) Give a background for the student's suggested compounds.

- b) Examine the suitability of the suggestions made by the student.
- c) Assess the response the tour guide gave to the student.

Item 65

The construction industry is rapidly growing in Uganda. A construction company is looking for a suitable material for glass, optical fibres and other construction materials. An industrial chemist has recommended considering electron affinities of Period 3 elements, melting points of a few selected oxides, and their reactions with water, and reactions of the selected oxides with alkalis and water and has provided the following information.

element	Na	Mg	Al	Si	P	S	Cl
Electron affinity (Kj/mol)	-20	+67	-30	-135	-60	-200	-364

Oxide	SiO ₂	P ₄ O ₁₀
Melting point (Oc)	1963	613

The company has taken up the advice from the industrial chemist and has also considered an assessment of environmental implications of the material.

TASK:
As a student of chemistry, analyse and interpret the data to address the company’s issues.

Item 66

A rural community located near a mining site is experiencing unusual health problems of chronic fatigue, respiratory illnesses and signs of radioactive exposure. Preliminary tests revealed presence of unknown radioactive substance W found in the surrounding bed rock which undergoes radioactive decay with bombardment of a neutron to produce Ba (mass number 144, atomic number 56) and Krypton (mass number 90, atomic number 36) with emission of two neutrons.

Water analysis also depicts elevated levels of Aluminium, Barium, Beryllium and Magnesium.

During further analysis of W using a detector, the activity was monitored overtime to ensure it remains safe. the results are recorded in table below

Time in minutes	0.0	5.0	15.0	20.0	25.0	30.0
Activity (counts per min)	25.00	23.00	21.25	19.50	18.00	15.25

Major concerns are on the identity of W and its half life, the reactions of the identified metals with water and sodium hydroxide solution and associated risks to the environment and possible mitigations.

Task: As a student of chemistry, analyse and interpret the data to address the company's concerns.

Item 67

A chemical plant is exploring use of one of Group VII elements in water treatment. The plant has been advised by an operations auditor on water quality factors to put into consideration bond dissociation energies of elements, their reactions with water and alkalis when deciding the element and has provided the following information.

molecule	F2	Cl2	Br2	I2
Bond dissociation energy (Kj/mol)	+158	+242	+193	+151

The plant's management is interested in the bond dissociation energy trend, reactions of elements and health implications of the applications of the element.

Task: As a student of chemistry make a write up to address the plant's management concerns.

ITEM 68

Physical properties of substances play important role in making choice for their use. Local investors from a community wanted to start a project of producing electronic gadgets which required use of electrolytes. They consulted the project planner who provided them with some compounds; Na2O, Al2O3, SiO2 and P2O5 and said that they should choose the one with lower melting point because this makes the process economically feasible.

The investors lacked adequate knowledge and approached the laboratory technician for help. The laboratory technician has instead identified you as a potential learner and asked you to give guidance. For effective implementation of the project the investors should have clear understanding as to how the compounds interact with water, sodium hydroxide and hydrofluoric acid. They should also have knowledge of the impact of the compound on the environment.

Task
Write a report that you will use in your presentation to guide the investors.

ITEM 69

The physical properties of elements have influence on their applications. A group of younger entrepreneurs wanted to develop idea of utilizing some elements in forming part of drilling equipment for use in society. They consulted their project planner and provided them with some information as shown below;

Elements	Diamond	Silicon	Tin	Lead
Melting point (Oc)	3730	1410	232	327

The project planner suggested that they should use the information provided in order to decide on the element to use. He also said for effective choice of material they should have knowledge on how the elements interact with water and sodium hydroxide. In addition, they must know the impact of the material on the environment. The entrepreneurs lacked sufficient knowledge and requested help. The laboratory technician has identified you as potential learner who can give guidance.

Task:
Write a report that you will use to give guidance to the entrepreneurs.

ITEM 70

Dr. Opio a medical physicist working in a large hospital. A patient, **Mr. Okoth**, has been diagnosed with a suspected cancerous tumor. To accurately locate and assess the tumor's size and spread, the medical team plans to use a diagnostic imaging technique involving a radioactive tracer. Later, **Mr. Patel** will undergo targeted radiation therapy to destroy the cancerous cells. **Mr. Patel** is scared of the prescribed proceedings.

Task: As a student of chemistry, you are requested to allay **Mr. Okoth's** fear by:

- a) Describe how a radioactive tracer (such as technetium-99m), is used in medical imaging to diagnose **Mr. Okoth's** condition. What properties make it suitable for this application?
- b) Discuss the principles behind radiation therapy and how it utilizes radioactivity to treat **Mr. Okoth's** cancer. What are the potential risks and benefits of this treatment?
- c) If the radioactive tracer used in the imaging has a half-life of 6 hours, and the initial dose administered to **Mr. Okoth** is 10 counts, how much of the tracer will remain in his body after 24 hours? Show your calculations.

END

