A'LEVEL CHEMISTRY SEMINAR HELD ON 10TH OCTOBER 2026

Item 1 scenarios

Item 1

Methanol is used in fuel cells and as a petrol additive, so its production process must be evaluated before large-scale production commences.

A company in Mbale Town is evaluating a two-step process for producing methanol from methane and steam, represented by the equations:

Step1: $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

Step 2: $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

It wishes to find the rate constant of the final stage of methanol production and an overall enthalpy change. So, a series of experiments were conducted at 500°C, and the following kinetic and thermochemical data was generated:

Table.1: Kinetic data.

Experiment number.	Initial [CO] ($moldm^{-3}$)	Initial [H_2] ($moldm^{-3}$)	Initial rate ($moldm^{-3}S^{-1}$)
1	0.010	0.010	0.005
2	0.020	0.015	0.030
3	0.010	0.030	0.015

Table 2: Thermochemical data.

Substance	$CH_4(g)$	$H_2O(g)$	$CO(g)$	$CH_3OH(g)$
Enthalpy of formation ($kJ\ mol^{-1}$)	-75	-242	-111	-201

An efficient process has a high rate constant greater than $1.0s^{-1}$ and an overall enthalpy change below +120 kJ mol^{-1} but they are unsure how to analyse the experimental data and justify whether the process is suitable, effect on both the rate and the yield of temperature, pressure, catalyst, and concentration. After visiting the facility, your teacher shared details of their intentions and wants you to evaluate.

Task:

Make a write-up that may help the company. Kololo S.S

Item 2

A metal-processing company in Uganda produces copper components used in electrical equipment. The company is reviewing its production processes to reduce energy costs while maintaining the required output. Its operations involve electrochemical cells, electrolytic recovery of copper, and chemical reduction of copper compounds.

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During a school-industry study programme, Senior Six learners joined the company's technical team to assess the efficiency and suitability of these processes.

In one section, engineers proposed an electrochemical cell made by connecting Zn^{2+}/Zn and Cu^{2+}/Cu half-cells under standard conditions. The cell is expected to supply electrical energy to monitoring equipment that requires a potential difference of at least 1.00 V. The engineers need to establish the electrode reactions, direction of electron flow, overall cell reaction and cell notation, and determine the electrical energy available from the cell.

Half-cell	E° / V
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76

In another section, copper is recovered from aqueous copper (II) sulphate by electrolysis using inert electrodes. During each operating cycle, a current of 19.3 A is passed for 2.00 hours. The company expects at least 22.0 g of copper to be deposited per cycle.

Production records showed that changes in the current supplied, duration of electrolysis, and concentration of Cu^{2+} ions in the electrolyte affected the operation of the recovery unit. The engineers therefore need to understand how these factors affect the process when selecting operating conditions that give adequate copper output without unnecessary energy use.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$. (Cu) = 63.5

The company is also analysing an alternative process in which copper (II) oxide is reduced using hydrogen:

$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$

The technical team wants to establish whether this reaction absorbs or releases heat, determine the associated energy change, and assess if it supports the company's efforts to reduce energy consumption.

Substance	$\Delta H^\circ f$ / kJ mol^{-1}
$CuO(s)$	-155
$H_2O(l)$	-286
$Cu(s)$	0
$H_2(g)$	0

As a member of the learner team, you have been asked to use the information provided and relevant chemical principles to help the company make appropriate technical decisions.

Tasks

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(a) Analyse the electrochemical and electrolysis information, explaining how the identified operating factors affect copper recovery, and advice on the suitability and effectiveness of the proposed processes.

(b) Evaluate the thermochemical information and recommend an appropriate production decision for the company.

Item 3

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-cell-powered 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 aqueous reactants, X and Y. They have been advised that a rate constant above 2.0×10^{-2} mol^2dm^{-6} s^{-1} and enthalpy of reaction above -150 kJ mol^{-1} represent an efficient production process.

The reaction is represented by the equation:

$2X\ (aq) + Y\ (aq) \rightarrow Products + H_2\ (g)$

One of the company's engineers argues that this very reaction can also be used to generate electricity based on its type.

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

Table 1: Initial Rate Data

Experiment	[X] ($moldm^{-3}$)	[Y] ($moldm^{-3}$)	Initial Rate ($moldm^{-3}$ 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	ΔHf° (kJmol^{-1})
X(aq)	-120
Y(aq)	-250
Products	-670
$H_2(g)$	0

The company also wants to investigate the conditions that affect the rate of hydrogen production.

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Task

a) Analyse the data provided and use it to help the company assess the efficiency of the production process and comment on whether the reaction can actually be used for electricity generation.

b) Explain the conditions that should be improved to maximize the production rate of the fuel.

c) Analyse how the law(s) used in the experiments conducted is important in real life and make a recommendation on the quality of a good fuel the company should consider.

Item 4

Uganda's transition to electric mobility has increased demand for rechargeable cells. A new factory in a certain town manufactures different cells and the Engineers are comparing two cell systems while also optimizing the heat released during electrode manufacture. A negative enthalpy of solution of the metal electrode salt represents an efficient electrode.

Laboratory measurements produced the following information.

Electrochemical Data

Set 1:	Set 2:
Cu^{2+}/Cu (+0.34 V)	Cu^{2+}/Cu (+0.34 V)
Zn^{2+}/Zn (-0.76 V)	Fe^{2+}/Fe (-0.44 V)

Thermochemical Data

Reaction	ΔH ($kJmol^{-1}$)
$Zn(s) + Cl_2(g) \rightarrow ZnCl_2(s)$	-415
$Zn(s) \rightarrow Zn(g)$	+130
$Cl_2(g) \rightarrow 2Cl(g)$	+242
$Zn(g) \rightarrow Zn^+(g) + e^-$	+906
$Zn^+(g) \rightarrow Zn^{2+}(g) + e^-$	+1734
$Cl(g) + e^- \rightarrow Cl^-(g)$	-349
$Zn^{2+}(g) + 2Cl^-(g) \rightarrow ZnCl_2(s)$	$\Delta H°_{lat}$ =?
$Zn^{2+}(g) \rightarrow Zn^{2+}(aq)$	-2045
$Cl^-(g) \rightarrow Cl^-(aq)$	-381

The factory is also considering a comparison between rechargeable and non-rechargeable type of cells.

Task

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(a) Analyse the data provided, use it to conclude on the best cell for use and efficiency of the zinc electrode.

(b) Explain the conditions that affected the values of the electrochemical potentials observed.

Help the factory to decide on the type of cell to use and explain how such cells can be of importance in real life

Item 5

Many manufacturing companies often face challenges of optimising production while reducing costs of production. A certain company located near a farming community uses ammonia as its raw material and ammonia gas availability affects production rate. Ammonia is obtained following the equation:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The production officer adds that enthalpy change of the reaction guides on prediction of temperature conditions for the reaction and an understanding of the rate equation with factors affecting it is key for quick ammonia gas yield.

He provided the data below.

Data set 1: Bond energies for some bonds

Bond	Energy ($kJ\ mol^{-1}$)
N≡N	945
H-H	436
N-H	391

Data set 2: Kinetic data for Haber process

Experiment number	Initial $[N_2]$ ($moldm^{-3}$)	Initial$[H_2]$($moldm^{-3}$)	Initial rate of reaction ($moldm^{-3}s^{-1}$)
1	0.2	0.15	3.0×10^{-4}
2	0.4	0.15	6.0×10^{-4}
3	0.4	0.45	1.8×10^{-3}

In the bid to relate with the community, the factory availed the above information to secondary schools for interpretation. Your chemistry teacher has extended the above information to you.

Task:

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(a) Analyse and interpret the suggestions made by the production officer and give necessary advice for improvement.

Advice the company on how they can appropriately use their raw material to help the community.

Item 2 scenarios

Item 1

Acids and salts have a wide range of applications in various fields however, care must be taken to avoid applying them in excess.

A community farm specializes in growing vegetables, which require a soil pH of 7.5 to 8.0 to thrive. Recently, the plants have become stunted and yellow. A local soil expert was consulted and suspects that the excess ammonium chloride the farmers have used for so long as a nitrogen source to boast growth is the likely cause. The expert carried out Laboratory analysis of the soil samples as summarized as;

- *20.0 g of the soil sample was dissolved in 400 cm^3 of distilled water.*
- *20.0 cm^3 of the resulting filtrate required 5.0 cm^3 of 0.02 M sodium hydroxide solution for a complete reaction using methyl orange as an indicator.*

Unfortunately, the expert could not provide further details due to an urgent call she received but instructed the farm manager to prepare 20 litres of a specific mixture using ammonia solution and ammonium chloride to maintain the soil at a target pH of 9.25 during a delicate seeding stage. The farm manager has about 200 g of ammonium chloride available and sufficient ammonia solution in his store with a concentration of 0.02M.

He wants to ascertain whether the available ammonium chloride will be sufficient for his needs, why the crops are failing to grow well in the soil, how temperature fluctuations can affect his mixture and how application of the prepared mixture can solve the problem. (K_b for ammonia is $1.8 \times 10^{-5}\ mol\ dm^{-3}$ at 25°C). Being unable to analyse the situations the farm manager decided to contact you for help.

Task: Help the farm manager address his concerns.

Item 2

The knowledge of steam distillation is widely employed in manufacture of pharmaceuticals. A group of senior five chemistry students went to visit one of pharmaceutical companies and were informed by the production manager that some raw materials used are aromatic compounds and their purification is by steam distillation and the process can be used to determine the molecular masses of the organic raw materials. He added that preliminary

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analysis show that one of the major raw materials is an organic compound which contains 77.4% carbon, 7.53% hydrogen and the rest being nitrogen and that the composition of the organic substance in the distillate during the purification process at different temperatures was determined for effectiveness. Themanager provided the students some of the data obtained during the purification process when distillation was carried out at 101kPa, where 1.6g of water and 1.1g of the organic raw material were obtained in the distillate.

Temperature (°C)	92	94	96	98	100
Vapour pressure of organic raw material (Nm^{-2})	6000	8000	12000	15000	17000
Vapour pressure of water (Nm^{-2})	74000	80000	88000	94000	101000

On reaching school the students still lacked knowledge on the principles involved during purification of the organic raw material, how the data provided can be used to arrive at the molecular formula of the raw material and other possible application of the method and have approached you for help.

Task: Make a write-up addressing the student's concerns

Item 3

The knowledge of volatile liquid mixtures and weak acid systems is essential in solvent recovery and industrial cleaning. A chemical manufacturing company in Uganda uses a solvent mixture containing methanol and cyclohexane. After production, the mixture is separated by simple distillation so that the solvents can be recovered and reused. However, the recovered solvents do not attain the required purity, leading to solvent losses.

To investigate the problem, the quality control laboratory measured the boiling points and methanol compositions in the liquid and vapour phases.

The results are shown in Table 2.

Boiling point of mixture (°C)	Mole fraction of methanol in vapour	Mole fraction of methanol in liquid
70	0.12	0.27
60	0.13	0.47
55	0.50	0.56
57	0.82	0.69

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61	0.94	0.83

The boiling points of pure cyclohexane and methanol are 81°C and 65°C, respectively.

The company also manufactures a cleaning formulation containing methanoic acid. During quality control, 50.0 cm^3 of 0.050 mol dm^{-3} methanoic acid was mixed with 50.0 cm^3 of 0.020 mol dm^{-3} sodium hydroxide at 25°C. During storage, 5.0 cm^3 of 0.020 mol dm^{-3} hydrochloric acid was accidentally added. The pKa of methanoic acid is 3.75. The company is investigating whether the formulation can maintain a stable pH and whether similar buffer systems could have other applications.

You were requested to investigate the problem and assist the company in understanding the causes of the solvent losses and the suitability of the cleaning formulation.

Tasks

(a) Analyse the quality control laboratory data to explain why solvent losses occur.

(b) Evaluate the suitability of the methanoic acid formulation for maintaining a stable pH and explain other applications of similar systems.

Item 4

Cement production in Uganda at a plant in Hima involves heating limestone ($CaCO_3$) to produce quicklime (CaO), which then reacts with other substances like sulphuric acid to form a sparingly soluble salt A (calcium sulphate), which is a highly versatile compound used across multiple industries. However, the production unit manager wants to find out the pH of a buffer system used in the cement slurry to control microbial growth, understand the effect of temperature on the solubility of A in water, how the solubility of A is affected when added to 0.01 M sodium sulphate, and the mass of A precipitated.

He researched and found the following ionic equilibria data which he could not use well:

Ka of ethanoic acid = 2.0×10^{-5} mol dm^{-3}

Solubility product (Ksp) of calcium sulphate = 2.4×10^{-5} mol^2 dm^{-6}

He prepared a buffer by mixing 800 cm^3 of 0.10 M ethanoic acid with 200 cm^3 of 0.20 M sodium ethanoate to control pH in the slurry, but microbial death occurred due to incorrect acidity. The engineer needs to establish if the pH of this mixture falls within a safe range (4.50 - 4.90). If it does not, he must determine the concentration of the salt required to adjust the pH exactly to 4.70 while maintaining the acid concentration of the initial mixture.

Additionally, he needs to calculate:

- The solubility of calcium sulphate in pure water.

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- The effect of 0.01 M sodium sulphate on the solubility of calcium sulphate (common ion effect).
- The mass of calcium sulphate precipitated when a given volume of saturated solution is mixed with the sulphate solution. He was referred to you for help.

Task

As a student of chemistry, help the manager address his concerns by preparing a report

Item 3/4 scenarios

Item 1

Oxides of period 3 elements are widely used in industrial applications and are common pollutants from industries due to their unique properties. Students visited a section of factory using magnesium oxide-lined furnaces when treating wastes and pollutants from industrial process. They wondered whether no other Period 3 oxides could provide better alternatives. The students discovered that the common pollutants treated in this industry are Silicon dioxide (SiO_2), phosphorus(V) oxide (P_2O_5), sulphur dioxide (SO_2), sulphur trioxide (SO_3). The solid wastes would be treated with calcium oxide directly, while the waste fumes would be passed through a tower packed with calcium oxide. The students are wondering about the chemical basis for these mitigations and the environmental impact of using the material chosen for the furnace lining and coating. Back at school the students were given the data in the Table 4 below by their teacher who accompanied them on the study trip.

Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3
Melting point (K)	1548	3150	2345	1986	573	290

Task

As a chemistry learner prepare a report that addresses the concerns raised by the students.

Item 2

Period 3 elements are widely used in industrial applications due to their unique physical and chemical properties. In one of the trade shows Manufacturers exhibited lightweight industrial components made of aluminium. One of the students from a certain school wondered whether other Period 3 elements could not provide better alternatives for the application. The exhibitor engineer explained that the choice of an element for a particular application depends on melting point and reactivity under aqueous, acidic or alkaline conditions. The students could not fetch chemical meaning from the engineer's explanations especially justification for the selection of the element, the safety and environmental effects associated with using the selected element. Back at school, the student has come to you with the data in Table 5 for help

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Element	Na	Mg	Al	Si	P	S	Cl
Atomic number	11	12	13	14	15	16	17
Atomic radius (nm)	0.191	0.160	0.130	0.118	0.110	0.102	0.099
Melting point (°C)	97.8	650	660	1414	44.2	115.2	−101.5

Task: As a chemistry learner, prepare a report that addresses the concerns raised by the student.

Item 3

The chemistry of halogens is employed in the manufacture of halogenated drugs. A newly established factory at Namanve Industrial Park specialises in the manufacture of drugs and has identified halogens as possible ingredients in the manufacturing process. However, the factory has failed to agree on the most suitable halogen for forming a stable C–X bond in drugs. They studying moist and strongly alkaline conditions to understand how the prosses can favour the drug manufacture. Senior six students have been given the data below to see if they can select the most suitable halogen as ingredient based on reactivity under moist and strongly alkaline conditions and if there are health implications of any selected element.

Element	Fluorine	Chlorine	Bromine	Iodine
Atomic radius (nm)	0.064	0.099	0.111	0.128
First electron affinity ($kjmol^{-1}$)	-328	-349	-325	-295

Task

Present a write-up that can be used to explain the factory's challenges

Item 4

A group of senior six chemistry learners visited an iron-processing company to learn how iron is extracted and how some of its compounds are used. At the company, iron-containing material was first crushed into smaller pieces. A magnet was then used to separate iron from some of the unwanted impurities. The learners observed that some particles were attracted to the magnet while others were not. The separated iron was then dissolved in dilute sulphuric acid to form a pale green solution of Iron(ii) sulphate. The chemist explained that iron (ii) sulphate has several uses. One important use demonstrated to the learners was its role as a catalyst in

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the reaction between potassium iodide solution and peroxodisulphate ions ($S_2O_8^{2-}$). The learners were also given samples of the iron(ii) sulphate solution. They carried out two tests;

- A sample of iron(ii) sulphate was acidified and potassium dichromate(vi) solution was added. The orange dichromate(vi) solution changed to green.
- To another sample of iron(ii) sulphate solution, sodium hydroxide solution was added. A green precipitate was formed which was insoluble in excess and turned to brown on standing.

The teacher explained that these observations provide evidence for the presence of iron(ii) ions.

At the end of the visit, the chemist warned the learners that careless disposal of iron(ii) sulphate-containing wastewater can have negative effects on the environment, especially when discharged into water bodies.

The company demonstrated the reaction between iodide ions and peroxodisulphate ions;

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

As a chemistry learner; prepare a report to address the concerns

Item 5

A group of scientists is studying a radioactive sample used to sterilize medical equipment.

The sample has been used for some time and it continuously emits radiations spontaneously. A team of learners was invited to analyse the sample. Their teacher told them that the sample can undergo different decays e.g. alpha decay, beta decay, gamma decay and positron decay.

The learners were provided with some data showing decay of the sample as shown below.

Time/min	0	4	8	12	16	20	24	28	32	36
Activity	800	640	512	450	328	262	210	168	134	107

The scientists want to understand the different emissions, determine the decay constant of the sample and assess the environmental implications of using the radioactive sample. You have been approached for help.

TASK

As a chemistry learner, prepare a write-up addressing the above concerns.

Item 5/6 scenarios

Item 1

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Organic compounds' properties and reactions determine their uses, synthesis and safety. A school science club visited a local agrochemical and plastics manufacturing company to learn how organic compounds are used to make useful products. They learned that chlorobenzene can be used as a herbicide and polyphenylethene as a heat-resistant plastic material. The students were also introduced to the use of bromoethane and propanoic acid as their respective raw materials. They now seek guidance on the physical properties that point at their suitability of each of the products (plastic and herbicide) their synthetic routes, reaction mechanisms of the first step of each reaction synthesis as well as the health implications of the products' applications.

Task

Help the students address their concerns. **Eden High School**

Item 2

Organic compounds are important industrial raw materials whose structures determine their physical properties and chemical reactions.

A chemical company in Iganga is producing paint removers and fragrances. It is now evaluating compound Q as a raw material. Q reacts with sodium metal to produce effervescence and exists as a non-cyclic isomer with different physical properties. The company plans to convert this isomer into propanone and 2-phenylpropene and into an ester for wider industrial use.

Management seeks guidance on:

- Explained choice of the most suitable isomer and the two useful solvents
- The mechanisms of the reactions involved in the formation of the ester and the first step in the production of the solvent.
- Mitigation plans of the potential long–term environmental
- The synthetic routes in conversion of Q into required products.

Task

As Chemistry learner, assist the workers to address their concerns:

Item 3

A chemical company produces organic compounds used as solvents, pharmaceutical intermediates and preservatives. The company has stocks of ethanol, ethene, benzene and benzoic acid that can be used as raw materials and is investigating ways of converting them into more useful products.

The production team intends to manufacture propan-2-ol from ethanol and propanoic acid from ethene. The proposed conversions may involve more than one reaction stage; therefore, the company needs to establish suitable intermediates, reagents, reaction conditions and equations for each production route.

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Before selecting suitable methods for handling and processing the substances, the company also needs to compare the boiling points and solubilities in water of ethanol, propan-2-ol, ethene and propanoic acid.

The company is further considering the production of phenylethanone from benzene and 3-nitrobenzoic acid from benzoic acid. To optimize these reactions, the production team requires an understanding of how the attacking species are generated, how they interact with the aromatic ring, the intermediates formed, and how aromaticity is restored.

Management must finally decide whether the proposed products are suitable for industrial production, taking into consideration their usefulness and possible health, societal and environmental implications.

As a Senior Six chemistry learner attached to the company, you have been requested to assist the production team.

Tasks

(a) Explain the observed differences in the boiling points and solubilities in water of the selected raw materials and products and relate them to their uses.

(b) Develop suitable synthetic pathways for obtaining the desired products from the available raw materials.

(c) Account for the formation of the aromatic products and advise the company on their production and use.

ITEM 4

A chemical and textile company manufactures packaging materials, synthetic fibres and aromatic intermediates. The company has stocks of ethene and benzene as major organic raw materials and is exploring ways of converting them into higher-value products.

Visiting chemistry learners have been told that one production line uses ethene to manufacture butan-1-ol. A second production line intends to make a monomer required for nylon 6,6. The company proposes converting benzene to hexanedioic acid through a multistep process. The production team has challenged the learners to determine the appropriate synthetic pathways. The packaging section also converts ethene to poly(ethene) and benzene to nitrobenzene. The learners are tasked with suggesting the reaction pathways that might be involved.

Quality-control staff have observed that poly(ethene) is flexible and insoluble in water, while nylon 6,6 has high tensile strength and low solubility in water and want to understand these properties and relate them to the uses of the polymers but they are also concerned about the environmental effects associated with polymer manufacture and disposal and how these can be controlled.

As a Senior Six chemistry learner attached to the production team, you have been requested to assist in analysing this information.

Tasks

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(a) Analyse the proposed synthetic pathways and account for the formation of poly(ethene) and nitrobenzene using appropriate reaction pathways.

(b) Provide relevant information that would help the quality control staff.

ITEM 5

A certain company that manufactures alcohols and polymer-based packaging materials has recently expanded its production.

The different production units use hydrocarbons obtained from petroleum as raw materials to manufacture the alcohols and polymers. Due to increased production, there is a scarcity of raw materials, and they have been advised that Methyl-2-methylpropenoate a raw material for Perspex, and ethene, a raw material for the plastic polymer polythene, can each be made using propanone as the starting material. In order to be able to control likely explosions, the company is seeking to understand how the reactions for the formation of polythene from its raw material and 1-bromopropan-2-ol from propene take place.

The company has been conditioned to effectively manage the disposal of waste materials from the plastic polymer, which is said to be non-biodegradable, and this has prompted them to seek to understand why it behaves this way and evaluate its use. The company lacks qualified personnel to help them do all the above and has advertised vacancies for those who can help. Your teacher, who read the advert, has provided you with this information.

Task

As a chemistry student, make a detailed write-up you would use to try to help this company.

ITEM 6

Many useful substances are obtained from organic compounds and are often converted into other useful substances through different chemical reactions. Recently, a chemical manufacturing company which uses propan-1-ol and ethyne as raw materials to produce products required by their customers complained about their different behaviors when heated. 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 ethanol and ethyne into 1-phenyl ethanol because the products were needed in the manufacture of other products. The company also needed to understand how the reactions for the formation of benzene sulphonic acid from benzene and ethanal oxime from ethanal occur.

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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;

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

ITEM 7

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 beverages, 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 (C_2H_5OH)
- Ethanoic acid (CH_3COOH)
- Propan-1-ol (C_3H_7OH)
- Ethyl ethanoate ($CH_3COOC_2H_5$)

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 the presence of sulphuric acid, but lacks information on how the reactions actually occur.

They also discovered that several products can be made from the same starting materials, and they consider preparing propyl benzoate 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 the 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.

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c) Assess the suitability of one of the compounds for use in the production of a specific product the company intends to make and suggest appropriate mitigation for its likely danger.

ITEM 8

An Agrochemicals industry manufactures herbicides, insecticides and plastic irrigation pipes used by commercial farmers. The industry recently partnered with researchers from a certain University to develop environmentally safer products after several farming communities reported contamination of groundwater and accumulation of plastic wastes in agricultural fields.

The research team advised that some petroleum-derived chemicals should be replaced with other environmentally friendly compounds. They proposed the preparation of N-phenyl ethanamide and 2-methylpropan-2-ol from ethyne, and a study of how the reactions leading to the formation of polychloroethene from chloroethene and propyne from 1,2-dibromopropane occur.

Laboratory trials also showed that ethene, benzene, methylbenzene and phenol initially used possessed markedly different boiling points.

The research team also proposed a thorough assessment of polychloroethene use before its manufacture commences. Your teacher wants to know if you can work as part of this research team and has decided to test you. Mpoma Royal College

Task

(a) Analyse the differences in the boiling points of the compounds observed during the laboratory trials.

(b) Make a detailed analysis of the proposals made by the research team

PRACTICAL SCENARIOS

Item 1

A small company uses magnesium powder to produce hydrogen for laboratory demonstrations. A recent batch produced less hydrogen than expected, and the technician suspects that unreactive impurities may have reduced the amount of magnesium in the powder.

The technician needs to determine whether the batch meets the company's **90%** purity requirement. The powder is believed to contain impurities that do not react with dilute sulphuric acid. He suggested weighing about **0.80 g** of powder Q, reacting it with **50.0 cm^3** of **2.0 $moldm^{-3}$** sulphuric acid, and then diluting the reaction mixture to **250 cm^3**. The unreacted acid in a measured portion of the diluted mixture is to be determined by back

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titration with sodium hydroxide, whose concentration must first be standardised using oxalic acid.

However, the technician could not obtain a reliable result because he was unfamiliar with standardising sodium hydroxide and calculating the excess acid after dilution. He therefore sought assistance from a technician at a nearby laboratory.

You are provided with the following

- FA1: 2.0 moldm^{-3} sulphuric acid
- FA2: sodium hydroxide solution
- FA3: solution containing 6.3g/l of oxalic acid ($H_2C_2O_42H_2O$)
- Magnesium powder labelled Q
- Phenolphthalein indicator
- Distilled water

The relevant reactions are:

$$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$$

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(C=12, O=16,H=1,Na =23)

Task

Design and carry out an investigation to assist the laboratory technician and advise the company whether the batch meets its purity requirement.

Item 2

Pregnant mothers require adequate mineral nutrients to maintain their health and support the proper development of the unborn baby. Deficiency of these nutrients may cause persistent tiredness, body weakness, dizziness and reduced ability to carry out daily activities.

At a local health centre, several pregnant mothers reported frequent tiredness, dizziness and general body weakness despite receiving dietary advice. Health workers suspected that the mothers might not be obtaining sufficient essential mineral nutrients from their diets.

The mothers were advised to use a newly developed nutritional supplement called PREGFIX, intended to provide essential mineral nutrients. However, the supplement had not yet been approved by the National Drug Authority. Before it could be administered or supplied to health facilities, the authority requested a qualitative analysis to verify the ions present. The

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findings would be used to determine whether the supplement should proceed to further quantitative analysis, contamination testing, clinical evaluation and safety assessment before approval.

Preliminary laboratory tests showed that the supplement was soluble in water. One suspected cation formed a precipitate that dissolved in excess sodium hydroxide solution, while the precipitate formed by the second cation remained insoluble. Further tests suggested the presence of two anions, but the investigation was not completed.

A sample of the supplement, labelled Sample A, was therefore submitted to the school laboratory for further analysis.

Task

As a chemistry learner assisting the National Drug Authority, design and carry out a systematic qualitative analysis of Sample A to identify the ions present and use the findings to advise on the suitability of the supplement for further medical evaluation.

Item 3

Organic compounds are important raw materials used in the manufacture of organic acids, perfumes, dyes, medicines, synthetic resins and food-preservation products.

Recently, several traders reported losses after fruit juices, sauces and baked products spoiled before reaching consumers. Manufacturers attributed the early spoilage to limited access to affordable raw materials needed to produce effective food-preservation products.

A group of young industrial chemists developed an affordable organic compound from molasses and maize, claiming that it could be converted into several useful products and reduce dependence on costly multiple raw materials.

Before purchasing the compound in large quantities, the quality-control manager requested an investigation to determine its chemical nature and usefulness as an industrial raw material.

A sample labelled Q was obtained. However, the company technician was unable to complete its identification and conversion, so it was referred to the school laboratory.

You are provided with Organic sample Q

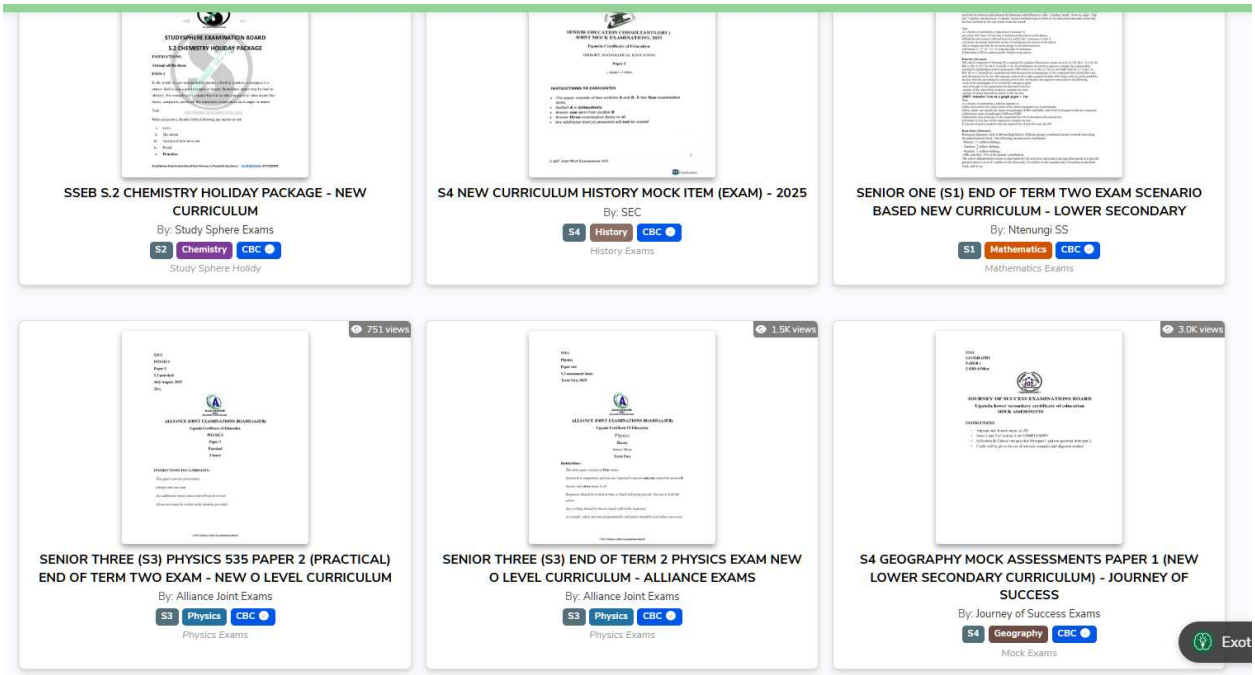
Task

(a) Design and carry out a systematic qualitative investigation of Sample Q.

(b) Use the experimental evidence obtained to make an appropriate recommendation about Sample Q.

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