BUDINSE MEMORIAL SCHOOL
PANIC TEST

S.6 CHEMISTRY PAPER ONE (P52/1), 2026

TIME: 2hours and 45 minutes

Instructions:

- √ Section A consists of two compulsory items
- √ Section B consists of part I and part II, attempt one item from each part.

SECTION A (compulsory)

ITEM ONE

A municipal water treatment plant in Kampala is evaluating different ionic compounds for use in softening hard water and removing toxic metal ions. The efficiency of these compounds depends on their solubility, stability, and energy changes during dissolution.

A team of chemists investigates three ionic compounds: MX, MY, and MZ, where M is a Group II metal and X, Y, Z are halide ions. They use Born–Haber cycles and thermodynamic data to determine which compound is most suitable.

Table 1: Thermodynamic Data

Quantity ($kJ\,mol^{-1}$)	MX	MY	MZ
Enthalpy of atomization of M	+150	+150	+150
First ionization energy of M	+738	+738	+738
Second ionization energy of M	+1450	+1450	+1450
Electron affinity of X / Y/ Z	–350	–300	–250
Bond dissociation energy of X_2/ Y_2/Z_2	+240	+200	+160

Enthalpy of formation (ΔH°f)	–800	–720	–650

Table 2: Hydration Enthalpies

Ion	Hydration Enthalpy (kJ mol⁻¹)
M^{2+}	–1900
X^-	–350
Y^-	–300
Z^-	–250

Task

(a) Using the Born–Haber cycle, calculate the lattice energy of compound MX.

(b) For compound MX, calculate the enthalpy of solution.

(c) Calculate and compare the lattice energies of MY and MZ.

(d) (i) Using your calculated lattice energies, predict which compound (MX, MY, or MZ) is:

- √ Most thermodynamically stable
- √ Most soluble in water

(ii) Explain your prediction in d (i) above

(e) Based on your analysis, recommend with reasons which compound should be used in water treatment in Kampala.

ITEM TWO

In an effort to reduce harmful emissions in urban areas, a fuel company in Kampala is developing a cleaner-burning petrol blend using two miscible liquids: ethanol (E) and cyclohexane (C). The mixture's volatility directly affects engine efficiency and emission profiles.

During testing, engineers observe that some mixtures behave ideally, while others show deviations from Raoult's Law, affecting vapor pressure and boiling characteristics. This has implications for fuel evaporation, storage safety, and air pollution.

You are part of a chemistry team tasked with analysing, modeling, and predicting the behaviour of these mixtures.

Given Data

At 25°C: Vapor pressure of pure ethanol=7.9 kPa and Vapor pressure of pure cyclohexane =13.0kPa

Table 3: Experimental Data for Mixture A

Mole Fraction of Ethanol (x_e)	Total Vapor Pressure (kPa)
0.0	13.0
0.2	11.9
0.4	10.8
0.6	9.7
0.8	8.6
1.0	7.9

Table 4: Experimental Data for Mixture B

Mole Fraction of Ethanol (x_e)	Total Vapor Pressure (kPa)
0.0	13.0
0.2	12.8

0.4	12.5
1.0	7.9

Tasks

(a) (i) Calculate the theoretical total vapour pressure when the mole fraction of ethanol is o.4 in mixture A. Compare the theoretical value with the experimental value in Mixture A and comment.

(b) Explain how intermolecular interactions account for the deviation of mixture B.

(c) (i) On the same axes, plot a graph of total vapor pressure against mole fraction of ethanol (x_e) for both mixtures.

(ii) Sketch the expected Raoult's Law straight line on the same graph and Comment on: Shape of curves and Deviation trends

(d) (i) Predict how the boiling point against composition curve would appear for: Mixture A and Mixture B

(ii) State whether Mixture B is likely to form an azeotrope, and justify.

(e) Evaluate the suitability of each mixture for fuel use

SECTION B (ATTEMPT ONE ITEM FROM EACH PART)

PART I (attempt one item of the two)

ITEM 3

In Uganda's expanding construction and agricultural sector, a government-supported company called East Africa Mineral Processing Limited processes Group II elements and compounds for use in cement production, soil treatment, medicine, and manufacturing industries.

During routine operations, engineers observe several chemical behaviours:

- √ Magnesium burns in air with a dazzling white flame, forming a white powdery oxide.
- √ Calcium reacts steadily with cold water, releasing bubbles of gas and forming an alkaline solution.
- √ Barium reacts more vigorously with water than calcium.
- √ When samples of Group II metals are placed in dilute hydrochloric acid, hydrogen gas is produced at different rates.

- √ Group compounds are widely used in cement production, agriculture, antacid tablets and manufacture of fireworks

However, challenges arise when improperly stored metal samples react with water, acids and air, leading to surface corrosion and reduced efficiency in industrial processes. The company now seeks to match the correct Group II elements and their compounds to appropriate industrial uses based on their chemical properties.

Task:

(a) (i)Describe the reactivity of Group II elements with the named chemical substances when improperly stored.

(ii) Account for the differences in reactivity observed among group II elements

b) (i) Explain why some group II , I and group III elements show similar chemical behaviour despite belonging to different groups

(ii) Describe two similarities in the chemical properties of a named group II element and a group III element

(c) A factory requires materials for the following purposes: neutralizing acidic soil, producing cement as a raw material, making fireworks and relieving excess stomach acid. Identify appropriate Group II element or compounds for each use and justify your choices based on their chemical properties and reactivity.

(d) Explain one environmental concern related to disposal of named Group II compounds and suggest a practical solution.

ITEM 4

A national materials research institute in Uganda is developing advanced materials for use in electronics, construction, packaging, and nuclear safety industries. The institute is studying elements of Group IV (carbon, silicon, germanium, tin, and lead) to determine their suitability for different technological applications.

During investigations, researchers observe that:

- √ Carbon exists in different forms with very high melting points.
- √ Silicon and germanium form strong covalent network structures used in electronics.
- √ Tin shows metallic properties and is widely used in coating metals.
- √ Lead has a high density and is used in radiation shielding but raises environmental concerns.
- √ Reactivity of these elements with air, water, and halogens varies

significantly down the group.

Table 5:

Element	Melting Point (°C)
Carbon (C)	~3550 (sublimes)
Silicon (Si)	1414
Germanium (Ge)	938
Tin (Sn)	232
Lead (Pb)	327

The institute requests a detailed chemical analysis to explain these trends and evaluate the applications and limitations of Group IV elements and their compounds in modern industry.

Task:

(a) Explain how melting point varies down the group

(b) Describe the reactions of group IV elements with air, water and halogens

(c) Explain the stability of oxidations states down the group in their compounds

(d) Evaluate the applications and limitations of Group IV elements and compounds in technology and industry

PART II (Attempt one item of the two)

ITEM 5

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 behaviour and the societal implications of alkyl halides used in the plant.

Tasks

(a) (i) Analyse 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
- √ 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 SIX

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:

Table 6:

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

(a) Analyse the structural differences between the compounds produced by the cooperative

(b) Compare and explain the physical property of the compounds produced by the cooperative in terms of boiling point.

(c) (i) Analyse the chemical behaviour of the compounds produced by the cooperative with the following reagents:

- √ Sodium metal
- √ Aqueous sodium hydroxide
- √ acidified potassium dichromate(VI)

(ii) Using equations, show how the primary alcohol can be transformed into a phenol via benzene

(d) Evaluate the uses of the compounds produced by the cooperative.

(e) Assess the health and environmental risks associated with: Contamination of alcohols; Toxicity and corrosiveness of phenols and propose practical and innovative solutions

END