P525/1
CHEMISTRY
Paper 1
July - August 2026
2¾ hours

KAMSSA JOINT MOCK EXAMINATIONS

Uganda Advanced Certificate of Education

CHEMISTRY

Paper 1
(Theory)
2 hours 45 minutes

Instructions to candidates

- *This examination paper consists of **two** sections; **A** and **B**.*
- *It has **six** examination items.*
- *Section **A** has **two** compulsory items.*
- *Section **B** has **two** parts; **I** and **II**. Respond to **only one** item from each part.*
- *Respond to **four** items in all.*
- *Any additional item(s) responded to will not be scored.*

All responses must be written in the answer booklet(s) provided.
Begin each item on a fresh page.

 Turn Over

ITEM 1

The Government of Uganda encourages local industries to increase the production of essential industrial chemicals using locally available raw materials to reduce dependence on imported products.

A small industrial plant near Kampala produces sodium hydroxide (NaOH) from locally mined rock salt (NaCl) from Lake Katwe. The NaCl is melted and electrolysed to produce sodium, which is then reacted with steam to form NaOH.

Recently, the plant management observed that production process largely depends on ***fuel and electricity***, making the production process much more expensive. They also noted that ***steel pipelines used to transport waste water are corroding more frequently***, increasing maintenance costs and interruptions in production. The management became concerned and recommended solutions including **coupling iron with metals**; however, ***they are cautioned that higher Emf from the metal couple with iron is not always preferred as*** it causes hydrogen embrittlement and paint blistering.

The information provided in Tables 1 and 2 has been provided to guide the analysis required.

Table 1 - Coupling metals

Metal	**Standard electrode potential (V)**
Fe^{2+}/Fe	−0.44
Zn^{2+}/Zn	−0.76
Al^{3+}/Al	−1.66

Table 2 - Atomic and molecular energetic data ($kJ \cdot mol^{-1}$)

Quantity (reaction)	**Value (kJ·mol−1)**
Atomisation of sodium: $Na(s) \rightarrow Na(g)$	+108
Bond dissociation of chlorine: $Cl_2(g) \rightarrow 2\ Cl(g)$	+243
First ionisation energy of sodium: $Na(g) \rightarrow Na^+(g) + e^-$	+496
Electron affinity of chlorine: $Cl(g) + e^- \rightarrow Cl^-(g)$	−349
Standard enthalpy of formation: $NaCl(s)$	−411

Task

a) Analyse the factors responsible for the increased fuel and energy cost in production process.
b) Using the information in Table 1, assist the management in choosing the suitable metal for coupling and analyse the proposed method.

ITEM 2

In industrial chemistry and agriculture, the correct control of concentration, temperature, pressure, and PH is essential for efficient production and safe use of chemicals.

A factory in Abim manufactures ammonia using the Haber process for use as a raw material in ammonium nitrate fertilizer production.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ **(-92 kJ/mol)**

The plant has been experiencing two major operational challenges:
(a) constant bursting of the reactor vessels, and
(b) an incredibly slow production process.
The production manager's log shows that they are currently operating at a temperature of **200°C** and a pressure of **400 atmospheres**. At this temperature, the theoretical equilibrium constant is $K_p = 4.30 \times 10^{-1}\ \text{atm}^{-2}$. *The structural engineer also notes that the reactor steel is only rated to withstand a maximum partial pressure of any single gas up to 300 atm before cracking.*

Furthermore, a local commercial farmer who has been buying large batches of ammonium nitrate fertilizer from the factory to boost corn yields, recently noticed the corn leaves turning yellow. The farmer took a sample of the soil solution near the root zones and found out that the concentration of the unreacted ammonium ion, $\mathbf{NH_4^+}$, **in the ground moisture was 0.05M**. *The farmer wants to understand if it was NH_4^+ causing yellowing of leaves and how he can save his crops.*
From literature, the acid dissociation constant for the ammonium ion at ground temperature is $K_a = 5.6 \times 10^{-10}$. Corn grows optimally only when the soil solution **pH** is kept strictly between **5.5 and 7.0**.

Task

a) Assess the factory's operational challenges in relation to the Haber process conditions provided.
b) Assess the effect of the fertiliser on agricultural productivity.

SECTION B

Part I

Respond to any* one *item in this part.

ITEM 3

A deep-sea mining and energy research company operating in the Erongo Region of Namibia recovered an unusually heavy radioactive mineral during exploration. Laboratory analysis using mass spectrometry revealed that the sample contains two previously isolated radioactive isotopes with unique nuclear properties.

Further investigations identified:

- ***Isotope X:*** *An isotope with atomic number **53** and an unusually high neutron-to-proton ratio ($N/Z \approx 1.63$).*
- ***Isotope Y:*** *An actinide isotope with atomic number **94** and mass number **244**.*

The company is considering refining Isotope Y into compact atomic battery packs for powering deep-sea monitoring sensors. However, some scientists have expressed concern that *accidental leakage or improper disposal of the radioactive material could pose risks to marine ecosystems and human health.*

During a laboratory meeting, the company manager sought clarification on the following issues:

*a) The most likely mode of radioactive decay that **Isotope X** will undergo in order to move towards the band of nuclear stability.*

b) *The expected mode of radioactive decay of* ***Isotope Y****, and why isotopes of elements with atomic numbers greater than 82 cannot maintain permanent nuclear stability.*

c) *A freshly isolated sample of* ***120mg*** *of Isotope Y has a decay constant of* ***0.0231 year^{-1}****. The manager wishes to determine the mass of the isotope that will remain after* ***90 years*** *of continuous deep-sea deployment.*

d) *Despite concerns raised by environmental scientists, the company intends to commercialise Isotope Y for use in consumer-grade maritime equipment to maximise profits. The manager therefore wants to understand the possible* ***health; environmental and ethical implications*** *associated with the use of this* radioactive material.

Task

a. Analyse the nuclear properties and behaviour of the two isotopes based on the information provided.

b. Justify the scientific explanations and recommendations that should be given to the company manager regarding the use and management of Isotope Y.

ITEM 4

Lead is widely used in the manufacture of lead-acid batteries for motor vehicles and backup power systems.

Your class visited Ssembuule battery manufacturing factory for a study tour. To guide your data collection, your teacher provided the following questions for investigation.

a) Why the company considered lead to be a suitable material for manufacturing batteries.

b) How lead released during battery production and recycling can react with oxygen and dilute acids to form different lead compounds.

c) *Why the company uses waste treatment facilities and recycling programmes* before *disposing of lead-containing wastes.*

At the factory, you presented these questions to the production manager who **provided the necessary responses**. He further informed you that *lead wastes are collected for recycling while wastewater containing lead compounds is treated with chlorine and filtered before discharge into the environment.*

During the production process, you observed that lead was ***easily melted, cast into battery plates and later used as electrodes in the finished batteries***. You also observed that fine lead dust and waste electrolyte were produced during manufacturing.

Task

a) Analyse the observations you made during the study.

b) Justify the responses provided by the production manager in regard to waste management.

Part II

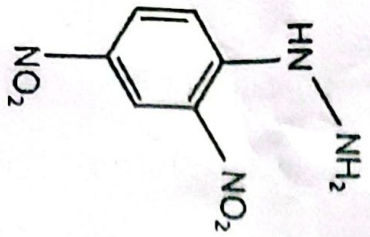
Respond to any one item in this part.

ITEM 5

A chemical manufacturing factory in Uganda produces **acetone (propanone)**, an important organic solvent used in the manufacture of nail polish removers, heavy-duty paint thinners and other industrial products.

At present, the factory obtains acetone from **propene** through a series of industrial chemical processes. During routine quality assurance, **laboratory technicians observed that acetone mixes readily with water and many organic solvents and evaporates rapidly under normal storage conditions.**

To ensure product quality, the **quality control department** routinely analyses samples of acetone using acidified **Brady's reagent**, which produces a yellow precipitate.



Due to growing concerns over the depletion of petroleum resources and the environmental impacts associated with their use, the factory is considering producing acetone from **ethanol obtained from biomass**. Before adopting the new process, *the production team requires information on the reaction mechanisms, synthetic pathway, reagents and conditions involved in converting ethanol into acetone.*

The environmental and safety department further emphasises that all raw materials and manufacturing processes must undergo impact assessment before approval to minimise risks to human health and the environment.

Task

a) Assess the observations made by the laboratory technicians.
b) Analyse the reaction mechanisms and synthetic pathway involved in the preparation and identification of acetone.
c) Provide a synthetic pathway for the proposed new production process of acetone.
d) Evaluate the industrial application(s) of acetone and assess the environmental implication(s) associated with its production and use, and propose appropriate mitigation measure(s).

ITEM 6

Organic compounds including aromatic compounds and alkyl halides are widely used in the manufacture of pharmaceuticals, agrochemicals, dyes and industrial solvents.

Kampala Pharmaceuticals uses these compounds as raw materials for the production of several industrial chemicals. The industry manufactures **chlorobenzene** and **nitrobenzene** from **Compound B**, while **Compound A** is used to produce **ethylamine, Propanenitrile** and **ethene** under different reaction conditions.

During a recent inventory carried out in the industry, the following compounds were identified in the chemical store:

- ***Compound A:*** *An alkyl halide containing two carbon atoms and one chlorine atom with a molecular mass of approximately* ***64.5****.*
- ***Compound B:*** *An aromatic hydrocarbon containing six carbon atoms with a molecular mass of* ***78****.*
- ***Compound C:*** *An aromatic hydrocarbon containing seven carbon atoms with a molecular mass of* ***92****.*

The suitability of each compound as a reactant depends on *its* ***solubility behaviour and boiling point***, which influence handling, separation and reaction efficiency.

Further information obtained during the study showed that the industry routinely carries out environmental and safety impact assessments before introducing any raw materials or products into large-scale production.

Task

a) Examine the compounds available in the store to determine their identity and physical properties in relation to their structures.
b) Analyse the reaction mechanisms and processes involved in the preparation of chlorobenzene, nitrobenzene, ethylamine, propanenitrile and ethene from the compounds provided.
c) Evaluate the industrial applications of compounds A, B and C, and recommend appropriate measures for their safe industrial use.

END