P525/1
Chemistry
Paper 1
July – August 2026
2¾ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS – 2026

UGANDA ADVANCED CERTIFICATE OF EDUCATION

Chemistry

Paper 1

2 Hours 45 Minutes

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of* **two** *sections* **A** *and* **B**.
- *Section* **A** *has* **two** *compulsory items.*
- *Section* **B** *has* **two** *parts;* **I** *and* **II**. *Respond to only* **one** *item from each part.*
- *All responses should be written on answer sheet(s) provided.*
- *Illustrate your responses with well-balanced equations where applicable.*
- *Where necessary, use the following:*
  - *Molar gas constant,* $R = 8.31\ JK^{-1}\ mol^{-1}$
  - *Molar volume of a gas at s.t.p* $= 22.4$ *litres*
  - *Standard temperature* $= 273\ K$
  - *Standard pressure* $= 101325\ Nm^{-2}$
- *Faraday's constant* $= 96500C$

SECTION A

Respond to **all items** *in this section*

1. Portable electrochemical power units and oxidising disinfectants are essential in rural health centres for sterilising reusable medical instruments and providing emergency electrical power during immunisation outreaches.

   To improve these services, the research team of a secondary school in Mityana developed a portable ***acidified dichromate(VI) based disinfectant*** for sterilisation and power unit for a nearby health centre and a power unit was constructed using the ***dichromate(VI)/chromium(III)*** and ***chlorine/chloride*** half- cell.

   During field trials, health workers observed that disinfectant stored in the outreach box during hot afternoons became ineffective much sooner than samples kept in a refrigerator at the health centre. They also found that a change in the energy associated with dissolving gaseous ions, changes electrode potential value at each electrode affecting the operation of the steriliser. To investigate these observations, .their supervisor provided them with the required electrochemical data while the students monitored the concentration of **dichromate(VI)** ions remaining in the disinfectant and obtained the following data.

Time (minutes)	0	10	20	30	40	50	60
Concentration (mol dm^{-3}) of dichromate(VI) ions	2.500	1.581	1.090	0.631	0.420	0.250	0.160

Electrochemical data

Half-cell reaction	***Electrode potential, $E^{0}(kJmol^{-1})$***
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	$+1.53V$
$Cl_2(g) + 2e \longrightarrow 2Cl^-(aq)$	$+1.36V$

The project being developed was not understood by the health workers and they sought help from the research team and the team has selected you to help in; analysing and interpreting the concentration data on a suitable concentration logarithm graph to estimate the storage efficacy by determining to half-life, considering a half-life of at least 10 minutes makes the disinfectant more efficient; interpreting disinfectant behaviour during trials; constructing the cell representation to evaluate the free energy change; and justifying optimal storage and electrode choices.

Task:

As the selected project team member, make a write up of the presentation to the health workers to make them understand and use the project being developed by the research team.

2. Thermal extraction using steam and pH regulating mixtures are commonly used in manufacturing industries to preserve product quality during processing and storage. To address a production problem, chemical engineers collaborated with an essential oils factory in Gulu to improve eucalyptus oil extraction for antiseptic formulations. During production, the team observed that increasing the heating temperature reduced both the yield and aroma of the oil, while fluctuations in the acidity of the blending tank caused variations in the quality and shelf life of the final antiseptic product. The factory therefore proposed steam extraction of the oil, *Q*, in eucalyptus and introducing a suitable buffer solution of *Q* during blending. The students collected the following data for steam extraction of a mixture containing 3.43% of *Q* at 101.3kPa;

Temperature (°C)	70	80	90	100	110
Vapour pressure of Q (kPa)	1.4	2.4	3.9	6.1	9.2
Vapour pressure of water (kPa)	19.0	47.0	72.0	104.0	132.0

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In the laboratory, the team weighed 0.56g sample of Q known to contain carbon, hydrogen, and nitrogen only and subjected it to complete combustion where 1.591g of carbon dioxide and 0.379g of water were collected and measured while a significant amount of soot was also observed.

On further analysis they added $35.0cm^3$ of 0.10M hydrochloric acid to $45.0cm^3$ of 0.10M solution of Q to prepare the blending solution. However, during one production run, a little sodium hydroxide accidentally poured into the mixture before packaging and this worried the workers, however, the laboratory technician guided that this should not worry them as the solution's pH will not be affected, and the laboratory technician informed them that the dissociation constant of Q was $4.2 \times 10^{-10} moldm^{-3}$.

Before approving the new production system, the factory management requested the engineers who lack sufficient theoretical principles to; justify the change in oil quality by predicting the outcome if direct heating or no buffer is used, analyse the steam distillation data on a suitable graph to and use the data to deduce the structural formula of Q and the pH of the blending solution, justify the laboratory technician's guidance on the stability of pH after accidental addition of sodium hydroxide, and understanding the applications of the system in the factory.

Your brother being the main chemist in the company has a very busy schedule and has requested you as a senior chemistry student to help him write a detailed report you will use to guide the engineers.

Task:

Write the report.

SECTION B

Part I

Respond to any one item *from this part*

3. Certain chemical elements play a vital role as raw materials in the production of substances that enhance hygiene and sanitation in everyday life.

A group of Senior Three students at a secondary school in Mbarara is participating in an innovation project to produce disinfectants and surface-cleaning agents using organic substances as solvents for use within the school and for sale to the surrounding community. The best disinfectant or surface-cleaning agent is one with the most oxidising ingredient. To help them select a suitable active ingredient, the laboratory technician provided information about three elements and the data shown below.

Element	**Fluorine**	**Chlorine**	**Iodine**
Action with water	Reacts vigorously	Reacts slowly	Slightly soluble
Boiling point (°C)	-188	-35	189
Standard electrode potential, $E^{\ominus}$ (V)	+2.87	+1.36	+0.54

The technician hinted that a suitable choice might emerge only after carefully weighing the given information against less obvious considerations such as environmental consequences and the differing ways each substance interacts with water and aqueous sodium hydroxide. Despite this guidance, the students found it difficult to draw meaningful connections from the data or to construct a well-reasoned justification for any particular option.

They have therefore sought your guidance to help them make an informed decision.

Task:

Help the learners address their challenge.

4. The relevance of some metals as raw materials for making different laboratory tools depend on their ability to withstand and respond to varying thermal conditions, their densities and how their chemical properties influence performance under practical laboratory conditions

An engineer at metal fabrication company is helping two teams of senior five students at a secondary school in Iganga to select metals for laboratory equipment. One team studied selected transition metals for heating apparatus, while another examined some Group 2 elements for lightweight fittings recoverable with alkalis and analyse the action of the selected alkaline earth metals on water.

To support their recommendations, the students compiled the following experimental data.

Group 2				
Element	***Be***	***Mg***	***Ca***	***Ba***
Atomic numbers	4	12	20	56
Density (gcm^{-3})	1.85	1.74	1.55	3.54

Transition metals								
Element	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Co**	**Ni**	**Cu**
Melting Point (°C)	1541	1668	1910	1907	1247	1495	1455	1085
Atomic numbers	21	22	23	24	25	26	27	28

Each section was required to interpret the data independently to identify the most suitable element for each assigned application with appropriate justification putting environmental concerns in consideration and elaborate on the action of alkali and water on the elements in the identified group.

The students' after confessing not to know Alkaline earth and transition chemistry have pleaded for guidance from the engineer.

As the class coordinator of Senior six chemistry class, you have been requested by the engineer to write a report that he will use to guide the senior five class.

Task:

Write the report, clearly highlighting all the issues and evaluation of any environmental impacts arising from the process.

Part II

Respond to any one item *from this part*

5. The production of pharmaceuticals, disinfectants and other industrial chemicals relies heavily on aromatic compounds because they serve as versatile intermediates in the synthesis of a wide range of valuable products.

   A pharmaceutical manufacturing company in Kampala is expanding its production line to dyes, pharmaceutical intermediates and household cleaning products. During the planning stage, the research chemists recommended using benzene as the starting material for preparing an intermediate compound X, through nitration, which would undergo further chemical transformations to produce one of the target pharmaceutical intermediates. However, the company's environmental management team warned that compound X is considerably more toxic than benzene. They therefore advised that any excess quantity remaining after production should be chemically converted back into benzene before storage or disposal in order to minimise health and environmental risks.

   The research team also established that benzene could be converted into another aromatic compound, Z, by chlorination and it can react with an alkyl halide in the presence of a halogen carrier to produce an intermediate required for the manufacture of biodegradable household detergents. Before commencing production, the company

management requested a detailed explanation of the reaction pathways, operating conditions, properties of the intermediates produced, and the environmental implications associated with each stage of the manufacturing process.

As the senior chemistry student attached to the project, you have been requested to prepare a technical report that explains, using reaction schemes with arrows, how compounds **X** and **Z** are synthesised from benzene, how excess compound **X** can be converted back into benzene, how **Z** can be converted to the intermediate for manufacture of the biodegradable household detergent the applications of the compounds formed, and the environmental hazards associated with the various processes.

Task:

Prepare the technical report that will be used during the company's production planning workshop.

6. A medium-sized specialty chemical company in Jinja plans to diversify its operations by manufacturing polymer-processing additives and industrial coating modifiers for use in the plastics and surface-engineering industries. After extensive product evaluation, the research and development team identified propanone hydrazone as a key raw material for the synthesis of polymer stabilising additives, while *cyclohexene*, was selected as an important raw material for producing coating-performance modifiers.

   To improve production efficiency and reduce procurement costs, the company resolved to manufacture these compounds in-house. Following consultation with industrial chemists, propanone and cyclohexanol were selected as the immediate cheaper precursor compounds required for the respective production pathways. Since ethanol is readily available from local bioethanol producers, it was chosen as the principal

feedstock from which both intermediates would first be synthesised before conversion into the desired products.

During pilot-scale process design, the technical team also recognised that large-scale production could generate excess unreacted reagents, undesirable side products and chemical wastes capable of increasing production costs and environmental pollution if not properly managed. Consequently, emphasis was placed on selecting efficient synthetic routes, maximising atom economy, recovering recyclable materials and adopting sustainable manufacturing practices to minimise waste generation throughout the production process.

Before commissioning the production line, the management team requires a technical evaluation of the proposed manufacturing strategy to determine the suitability of the selected raw materials, critically assess the methods for converting ethanol into the required intermediates, and using arrows to analyse the subsequent transformations leading to the target intermediates for industrial production.

Task:

As a Senior Chemistry student, prepare a concise technical write-up that addresses the company's concerns.

END