Candidate's Name:……..……..**Signature:** ……

525/1
CHEMISTRY

April 2026
2 hours

RWENZORI HIGH SCHOOL
Uganda Advanced Certificate of Education
S.6 CHEMISTRY
Paper 1
2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

This paper has two sections A and B.

Section A has two compulsory items while B has two parts

Part I and Part II

Each of part I and part II has two items, Answer only <u>one</u> from each.

Answers to Section A <u>must</u> be written in the spaces provided and Section B <u>must</u> be written in the answer booklet(s) provided

Answer four in all.

Where necessary use,

Molar gas volume at s.t.p = 22.4dm^3

SECTION A

Answer all questions in this section

ITEM 1

Dr. Kuule, a nuclear physicist at Kabale University is carrying an experiment involving a radioactive sample of iodine-131, commonly used in medical treatment and it has a half-life of 8 days. If the initial activity of the sample is 1000 Bq,

Task:

a. Calculate the;

i. number of half-lives that have passed after 24 days.

ii. activity of the sample after 24 days.

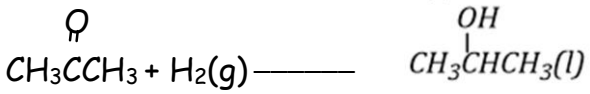
b. Explain the significance of half-life in radioactive decay.

c. Discuss the applications of radioactive iodine-131 in medicine

d) Explain the safety protocols that should be followed when handling radioactive materials like iodine-131, and discuss the potential health risks associated with exposure to ionizing radiation

Item 2

A chemical processing plant plans to scale up production of propan-2-ol, an important solvent used in sanitizers. Plant managers are evaluating two possible preparation routes, and the management wants a full thermochemical assessment before commissioning either pathway. Major preparation involves hydrogenation of Propanone:



Alternatively, propan-2-ol can be obtained from hydration of propene:

$CH\ CH = CH\ (g) + H_2O(l)$ ——— $CH_3\overset{OH}{\overset{|}{C}}HCH_3(l)$

The thermochemical department has supplied the following bond energies and auxiliary standard enthalpy information for use:

Bond / Data	C=O	C=C	C–C	C–H	C–O	O–H	H–H
Value ($kJ \cdot mol^{-1}$)	715.41	614.28	345.01	414.50	351.11	464.23	436.43

To inform decision making for the best preparation reaction the manager has been advised by the expert that the best reaction must be feasible therefore you have been contacted for help.

Task:

As a learner of chemistry, help the manager

(a) For each route, construct a Hess's law energy cycle, using the thermochemical data.

(b) Use the energy cycles above to calculate the enthalpy change for:

(i) Hydrogenation of propanone

(ii) Hydration of propene

(c) Evaluate which preparation route is more feasible for large scale production of propan2-ol in the factory.

(d) Predict any major environmental impact arising from the process and propose a realistic mitigation measure for the impact.

SECTION B

Part I

Attempt One item in this section

Item 3

A pharmaceutical firm uses Aluminium chloride to synthesise a hemostatic agent, a chemical used to stop bleeding during surgical operations in theatres. The Aluminium metal powder is reacted with chlorine under special conditions to form the Aluminium chloride. However, other metal elements can react with chlorine more easily. In the preparation cell are two identical metal powders in cans labelled X and Y.

The details of the metals in the cans are summarized in terms of ionization energies as shown in the table below.

Ionization energy		1st	2nd	3rd	4th
Energy values KJmo1^{-1}	X	578	1,817	2,745	11,600
	Y	738	1,451	7,733	10,542

Hakim a new worker in the preparation cell is confused of which of the two metal cans is of Aluminium powder. As a chemistry student, you are aware that for Hakim to be able to analyse and identify the right aluminium can, he should know a lot about the chemistry of Aluminium metal.

Task: Help Hakim to;

(a) (i) Write the electronic configurations of Aluminium and its ion. (2 scores)

(ii) Write the electronic configuration of the atom and the ion with which Aluminium forms the hemostatic agent (2scores)

(iii) Demonstrate how the compound in the Hemostatic agent is formed (2scores)

(iv) State the type of bond, physical properties and any other use of the compound in the hemostatic agent.
(3scores)

(b) (i) On the same axes, plot a graph of energy values against Ionization energies for both metallic elements X and Y (4scores)

(ii) Describe the trend in Ionization energy values for each metallic element (2scores)

(iii) According to your graph, which of the elements X and Y is more thermodynamically stable? Explain (2scores)

(c) (i) It is indicated that the remaining element after identifying Aluminium is found in period 3 of the periodic table. Name the element, write its electronic configuration

and show how it can form a compound with chlorine if mistakenly used instead of Aluminium. (4scores)

(d) It is said that excess sodium hydroxide solution can be used to separate the two cations; Aluminium and either X and Y in a solution mixture. One forms insoluble precipitate in excess while the other forms soluble precipitates. Explain with equation(s) the difference in the observations.

Item 4

Uganda faces persistent challenges in rural electrification. Many communities rely on unreliable and costly energy sources like diesel generators, kerosene lamps, and car batteries. A Ugandan company is developing solar-powered micro-grids and has invited your chemistry class to help identify suitable materials for solar batteries and wiring. These materials must be affordable, corrosion-resistant, and durable under Uganda's rural conditions.

The company is investigating elements similar to those in Periods 2 and 3 of the Periodic Table. The measured properties of selected elements are shown below:

Element	Atomic Radius (pm)	First Ionization Energy (kJ/mol)	Electronegativity (Pauling)	Typical Bonding Type
Li	145	520	1.0	Metallic
Mg	130	730	1.5	Metallic
Al	110	1000	2.5	Metallic
Si	95	1250	3.0	Covalent
P	85	1500	3.5	Covalent

Task As a chemistry learner;

Use your understanding of atomic structure, periodic trends, chemical bonding and the information provided to propose suitable materials for solar batteries and wiring in Uganda's rural micro-grid systems

Part II

Attempt One item in this section

ITEM 5

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 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.

ITEM 6

A chemical industry dealing in production of an aromatic organic chloride from an organic substance and an aliphatic alcohol R from an alkene Q hid its production schemes from the Uganda national Bureau of Standards (UNBS) for confidential purposes.
A UNBS inspector landed on the production manual that contained the information as follows below.
"P will be obtained from limestone (Calcium carbonate) and coke (carbon) as the primary raw materials. P has molecular mass 78. 92.31% of which is carbon and the rest being hydrogen while Q has molecular mass 56 with 85.71% carbon and the rest being hydrogen".
The manual further revealed that, P is reacted with chlorine of anhydrous Aluminium chloride to form the aromatic chloride. The resultant inorganic product of this reaction is not wasted but it rather directly reacted with Q in either presence or absence of an organic peroxide depending on the chemical market demand. Q is isomeric with three compounds among which only one is the desirable.
One of the two undesirable isomers is said to have a very low boiling point and hence forms a very volatile type of alcohol that is un easy to store for longer.
The second undesirable isomer is neglected just because it forms only one type of alcohol yet the desirable one forms two isomeric alcohols. The resultant compound from the latter reaction of Q under the organic peroxide is passed through alcoholic sodium hydroxide to obtain the final desired alcohol"
The UNBS inspectorate failed to interpret and understand what the production manual described and so, you have been consulted as an authority of chemical analysis.

Task

Help the inspectorate to;

(a)(i) Determine the molecular and structural identity of compound P

(ii) Explain and illustrate the course of production of P from the primary raw materials as described in the manual.

(b) Show how the aromatic chloride is obtained from P (Indicate acceptable mechanism for the reaction)

(c) (i) Name and write the molecular and structural formulae of the three isomers of Q

(ii) Identify the undesirable isomer whose alcohol is very volatile and explain why

(d) Explain how the inorganic product formed with the aromatic chloride is used to convert the desirable isomer of Q into a desirable chloride (show the acceptable mechanic where possible)

(e) Show how the isomeric chlorides obtained in d(i) and d(ii) above are converted to the desirable isomeric alcohols.

END

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Te 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Ti 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															
			139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 68	173 Yb 70	175 Lu 71
			227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

END