Candidate's Name: ……..……..

Signature: ……..

STREAM:							

525/1
CHEMISTRY
March 2026
$2\frac{1}{2}$ hours

PRE-REGISTRATION ASSESSMENT 2026

Uganda Advanced Certificate of Education

S.6 CHEMISTRY

Paper 1

Set I

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 **one** *from each.*

Answers to Section **A** ***must*** *be written in the spaces provided and Section* **B** ***must*** *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

FOR EXAMINER'S USE ONLY		
ITEM	**CODE**	**SCORE**
1		
2		
3/4		
5/6		
TOTAL		

SECTION A

Answer **all** *questions in this section*

ITEM 1

PhosGuard Industries manufacture phosphorus-derived reagents used in water treatment to remove heavy metal poisoning. Part of their continuous firing reactor line handles phosphorus(V) chloride (PCl_5) as an intermediate. The safety team performs gas phase equilibrium checks to ensure plant safety and downstream water treatment compatibility.

A gas phase equilibrium test was carried out by introducing *3.60 moles* of phosphorus(V) chloride into a rigid vessel of volume *2.00 dm³* at a given temperature. Analysis showed 1% dissociation according to:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \quad \Delta H = +124\ kJ\ mol^{-1}.$$

Using this information, the equilibrium constant Kc can be determined.

In a follow-up process optimization test, the company introduces an additional 0.050 moles of chlorine gas (Cl_2) into the same system at the same temperature.

A treatment test was carried out where *0.208 g* of phosphorus(V) chloride (PCl_5) was completely hydrolysed in *1.00 dm³* of water, producing hydrochloric acid (HCl).

The acid produced supplies chloride ions (Cl^-), which are then used to react with lead(II) ions (Pb^{2+}) in wastewater to form a precipitate, equations involved;

$$PCl_5\ (g) + 4H_2O\ (l) \rightarrow H_3PO_4\ (aq) + 5HCl(aq)$$

$$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$$

A sample of wastewater contains 0.020 mol dm^{-3} Pb^{2+} ions. You have been contacted for help.

Task:

As a learner of chemistry, guide the company on how to:

(a) Calculate the equilibrium constant Kc and comment on the extent of the reaction.

(b) Determine the new equilibrium concentrations of all species during optimization test, hence determine the direction in which the equilibrium shifts and explain your answer.

(c) Explain what would happen to the equilibrium position, the equilibrium constant (Kc) and the speed of attainment of equilibrium when the following changes are made:

i. Increasing the temperature

ii. Decreasing the pressure

iii. Adding helium gas at constant volume

(d) Advise the company on how to optimize operating conditions (temperature, pressure, concentration) in order to, control equilibrium effectively, improve production efficiency and ensure safety in handling phosphorus(V) chloride

(e) Calculate the maximum number of moles of Pb^{2+} ions that can be precipitated by the chloride ions present, Comment whether chloride ions are sufficient to completely remove Pb^{2+} ions from the wastewater.

(f) Suggest possible environmental impacts PhosGuard Industries should beware of and propose appropriate mitigation measures.

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:

$$CH_3\overset{\overset{O}{\|}}{C}CH_3 + H_2(g) \longrightarrow CH_3\overset{\overset{OH}{|}}{C}HCH_3(l)$$

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

$$CH_3CH = CH_2(g) + H_2O(l) \longrightarrow CH_3\overset{\overset{OH}{|}}{C}HCH_3(l)$$

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·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 propan-2-ol in the factory.

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

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SECTION B

Part I

Attempt **One** *item in this section*

Item 3

Your chemistry class has been invited by a chemical plant management near Lake Victoria to assist in identifying ways of optimizing the production of key industrial compounds including sodium oxide, magnesium oxide and silicon dioxide used in glassmaking and ceramics. The plant management has observed inconsistencies in melting points and reactivity, which are affecting product quality and safety. You are tasked with conducting a scientific investigation to analyze periodic trends of the elements, compound properties, and molecular structures to recommend improvements.

Important chemical data of the findings about the elements and their compounds is provided in the table below to assist in the analysis.

Element	**Atomic Number**	**Atomic Radius (pm)**	**Ionisation Energy (kJ/mol)**	**Melting Point (°C)**	**Oxide Melting Point (°C)**
Sodium (Na)	11	186	496	98	1275

Magnesium (Mg)	12	160	738	650	2800
Aluminium (Al)	13	143	578	660	2072
Silicon (Si)	14	118	786	1410	1710
Phosphorus (P)	15	110	1012	44	580
Sulphur (S)	16	104	1000	115	Gas/Sublimes
Chlorine (Cl)	17	99	1251	-101	Gas/Gas

Task

As a chemistry learner, write a report about the periodic trends of the elements and their oxides, and recommend improvements to the plant's production processes.

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 agro-processing 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-3-methoxybenzaldehyde).

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

In southwestern Uganda, a small cosmetics start-up is producing herbal skin-care creams using locally sourced plant oils, such as shea butter and sunflower oil. The production process generates significant amounts of waste plant oils and fats. These wastes are currently disposed of into nearby drainage systems, causing blockages and foul smells, which has led to complaints from the community and environmental authorities.

The company has approached a team of A-level chemistry students in your school to:

1. Analyse the composition of these waste materials, their functional groups and physical properties,
2. Explore possible chemical processes to convert them into valuable products and their mechanisms,
3. Design a synthetic route to convert compound C into compound D

4. Propose a sustainable chemical process to convert waste A into a useful, marketable product that reduces environmental harm.

Analysis of a sample of the waste oil revealed the presence of a mixture of the following compounds:

Compound	Structure (condensed)
A	$CH_3(CH_2)_{14}COOCH_2CH(OH)CH_2OH$
B	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
C	$CH_3CH_2CH_2OH$
D	CH_3COCH_3

Tasks:

As a chemistry learner, give written presentation that addresses the company's challenges and outlines scientifically sound, sustainable solutions.

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