P525/1

CHEMISTRY

Paper 1

April 2026

$2^{3}/_{4}$ hours

Uganda Advanced Certificate of Education

S.6 CHEMISTRY

Paper 1

(Theory)

2 HOURS 45 MINUTES

INSTRUCTIONS TO CANDIDATES

*This paper **two** sections; **A** and **B.** It has six 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*

Responses to both sections must be written in the answer booklets provided

*Responses to each item must start on **a fresh page***

All items carry equal scores

*Any additional item(s) answered will **not be scored***

*Where necessary; use the following: **Cl=35.5, O=16, C=12, Be=9, H=1, Molar gas constant=8.314KJ/mol***

SECTION A

Respond to all items in this section in the answer booklets provided

Item 1

1a) Archeologist at the Bigobyamugenyi site use carbor-14 dating on a wooden aircraft. They find it has 25% of the original carbon -14 activity. This isotope decays predictably, with a half-life of 5730 years, allowing them to accurately date the ancient settlement and understand Uganda's early history. The team must calculate the aircraft's age to confirm the site's timeline

TASK

i) Write the nuclear equation for the beta decay of carbon-14

ii) Given that the half-life is 5730 years, calculate the age of the wooden aircraft

iii) State one assumption made in carborn-14 dating

b) An anesthetist at the nearby hospital who treats the archeologists uses nitrous oxide (N_2O). A student asks about its structure and the doctor explains that its linear shape and specific bonding make it suitable as an anesthetic. understanding it's Lewis's structure and properties ensure safe and effective use in surgical procedures, a key skill for medical professionals in Uganda.

TASK

As a student of chemistry,

i) Draw the Lewis structure for N_2O

ii) Use VSEPR theory to predict the molecular shape of N_2O

iii) State the approximate bond angle in the molecule

Item 2

An industry located in Kitezi land hills dealing in production of metals, ceramics and battery recycling is designing a high temperature resistant coating for industrial furnaces used in steel rolling mills. The project requires evaluating Aluminum oxide (Al_2O_3), lead (ii) nitrate [Pb $(NO_3)_2$] and sodium Fluoride (NaF) in order to make best choice of most stable substance during formulation to apply in ceramics, abrasives and furnace lining

The company also wishes to select a substance in which temperature control depends on

dissolution in water to use as a cooling agent and stabilizing agent in chemical preparation units. Thermochemical data obtained from industrial material's report the following values in table 1. However, the company discharges metals during battery recycling in water and water quality Surveillance unit discovered heavy metal contamination in a borehole supplying a large number of households.

A fragment of a metallic lead was analyzed using mass spectrometer and the detector registered four isotopic signals with currents of **0.16mA (mass 204),2.72mA (mass 206),5.92mA (mass 208) and 2.5mA (mass 207).** Further lab tests revealed that the dissolved salt was lead (ii) nitrate. The concentration of the salt in the borehole water measured as 0.9mol/L and the borehole supplies **1200litres** of water per day. Chemists concluded that the salt can be removed by treating the water with sodium sulphate which reacts to produce insoluble lead(ii) sulphate

Table 1

Na(s) ⟶ Na(g): +109kJ/mol	**Al(s) ⟶ Al(g): +330KJ/mol**
1st ionization energy of Na: +494kJ/mol	**1st ionization energy of Al: +578KJ/mol 2nd ionization**
Bond dissociation energy of F: +158kJ/mol	**energy of Al: +1820KJ/mol 3rd ionization energy of Al: +2750**
1st electron affinity of F: -328kJ/mol	**kJ/mol**
Enthalpy of formation of NaF: -569kJ/mol	**Atomization energy of Oxygen: +249kJ/mol Lattice energy of**
$Na^+(g)+(aq)$ ⟶ $Na^+(aq)$: -406KJ/mol	**Aluminum oxide: -15346.5kJ/mol 1st electron affinity of Oxygen: -142kJ/mol**
$F^-(g) + (aq)$ ⟶ $F^-(aq)$ -505kJ/mol	**2nd electron affinity of Oxygen: +798kJ/mol**

$Pb(NO_3)_2(aq) + Na_2SO_4(aq)$ ⟶ $PbSO_4(s) + NaNO_3(aq)$

The ministry of health and energy has invited you for help provide

stoichiometric and methodological evaluation of the situation.

Task

a) Analyze the thermochemical data carefully to construct an energy level diagram for changes in the;

i) Formation of Aluminum oxide

ii) Formation of NaF

b) Use the cycles or diagrams above to calculate;

i) Enthalpy of formation of Aluminum oxide

ii) Lattice energy of NaF and its enthalpy of solution

c) Evaluate the industrial usefulness of the two systems to advise the manager which substance is most suitable for furnace lining and cooling applications

d) i) Help the manager determine the RAM of lead in water

iii) Calculate the mass of lead(ii) sulphate formed if all the dissolved salt was removed

iv) Suggest possible impacts of the process and mitigation of the substances to the environment

SECTION B

Part 1

Attempt one item from this part

Item 3

A rural community located near a mining site is experiencing unusual health problems of chronic fatigue, respiratory illnesses and signs of radioactive exposure. Preliminary tests revealed presence of unknown radioactive substance W found in the surrounding bed rock which undergoes radioactive decay with bombardment of a neutron to produce Ba (*mass number 144, atomic number 56) and Krypton (mass number 90, atomic number 36) with* emission of **two** neutrons. Water analysis also depicts elevated levels of Al, Ba, Be and Mg. During further analysis of W using a detector, the activity was monitored overtime to ensure it remains safe.

The results are recorded in table below

Time in mins	0.0	5.0	15.0	20.0	25.0	30.0
Activity (counts per min)	25.00	23.00	21.25	19.50	18.00	15.25

Major concerns are on the identity of W and its half-life, its associated risks to the environment and possible reactions of elements in water. The ministry of energy has contacted you for help.

Task:

As chemistry student;

a) i) Plot a graph of activity of W against time
   ii)Determine the half-life of W, its decay constant and comment on your answers
   iii)Identify the unknown substance W
b) Predict how the identified metals in water react with;
   i) Water
   ii) Sodium hydroxide solution
   iii) Concentrated sulphuric acid
c) Discuss the impacts of the mining operations to both health and environment and possible mitigations
d) Explain any other possible applications of radioactivity in industry and medicine

Item 4

Victoria Industrial Chemicals Ltd produces industrial grade materials for construction, ceramics and high temperature processes. Engineering department is investigating the use of group 2 and period 3 compounds (oxides and sulphates) to select the suitable material for industrial applications. The baseline requirement is that a suitable substance must remain solid above 1400°C ,have strong ionic bonds, mechanically stable during operations and and reduced solubility in water treatment processes.

Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6	P_4O_{10}	SO_3	Cl_2O_7
Melting point in °C	1275	2827	2007	1607	24	560	30	-92

Group (II) sulphates

Sulphate	$BeSO_4$	$MgSO_4$	$CaSO_4$	$SrSO_4$	$BaSO_4$
Solubility	43	36	0.2	0.011	0.0024

The engineering team requires a comparative analysis of the oxides and sulphates for use in industrial purposes while monitoring the environmental risks of the operations. The company has approached a team of A level chemistry students to address the following

- Plot graphs of melting points of the oxides and explanations of trends
- Description of trend in the solubility of sulphates of group (II)
- Prediction of reactivity of the oxides with alkalis and water
- Possible impacts of the operations to environment and mitigations

Task:

As the chemistry coordinator, prepare a write up for your presentation to the company

Part II

Item 5

Albertine chemical facility produces fuels solvents and organic feed stocks used in plastics disinfectants additives in food and other chemical synthesis. During a research study organic compound P was isolated from a distillation unit which on complete combustion it burnt with a sooty flame and yielded 8.8g of carbon dioxide, 1.8g of water. When 0.100g of P was vaporized at 273°C and 734mmHg it occupied a volume of $4.46X10^{-2}$ dm^{-3}. Treatment of P with acidified water and heat yielded compound Q which on oxidation in presence acidified

potassium dichromate (VI) yielded a ketone. The industrial chemists seek to know the

nature of Q and its use in industrial applications.

You have been contacted for help.

Task:

- ✓ Determine the molecular formular of P and hence its identity
- ✓ Identify compound Q and the ketone and any equations mechanisms leading to their formation where possible
- ✓ Propose appropriate mechanisms for;
  - i) Reaction of P with Bromine water
  - ii) Conversion of P to phenyl ethyne used in plastics (include mechanisms for all steps involved)
- ✓ Using appropriate reagents and conditions show how;
  - i) P can be converted to any carboxylic acid
  - ii) P can be converted to benzene
  - iii) P can be converted to 3-phenylpropan-1-ol
- ✓ Discuss the environmental impacts of producing the associated compounds

Item 6

A small cosmetic start up is producing herbal skin care creams using locally sourced materials. The production process generates significant amounts of waste materials which are currently disposed into nearby drainage systems, causing blockages and foul smells which has led to complaints from the community and environmental authorities. Analysis of a sample of oil revealed of mixture of the following compounds.

Compound	**IUPAC name**
A	Propan-1-ol
B	Propanone
C	Methylbenzene
D	But-2-ene

The company has approached chemists in your school to;

- Analyze the composition of these waste materials, there functional

groups and any physical properties

- Design synthetic routes to;

✓ Convert D to Ethanol a disinfectant

✓ Convert A to B

✓ Convert C to benzoic acid

✓ Convert B to a propyne

- Explore possible mechanisms for reactions of C;

✓ with conc nitric and conc sulphuric acid

✓ Fuming suphuric acid

✓ Chlorine

- Discuss the impacts of compound C to health and environment

Task: Prepare a write up for your presentation

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 Tl 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 69	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