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P525/1
CHEMISTRY
Paper 1
(Theory)
April, 2026
2¾ Hours

GUIDE

MENGO SENIOR SCHOOL

Uganda Advanced Certificate of Education

END OF TERM I ASSESSMENT 2026

S.5 CHEMISTRY

PAPER 1

2 HOURS 45 MINUTES

INSTRUCTIONS TO CANDIDATES:

- This paper consists of **four** examination items.
- Attempt **all items** in Section A and Section B.
- Responses to items in Section A are to be written in the spaces provided while in Section B part I (Inorganic) and part II (Organic) **must** be written on separate answer booklets.
- Use **blue** or **black** ink.
- All working must be clearly shown.
- Graph paper is provided.
- A Periodic Table is provided.
- Mathematical tables and silent non- programmable calculators may be used.
- You are advised to carefully read each item and the **plan** appropriately before starting.

For Scorer's Use Only

Item	1	2	3	4
Weighted Score				
Scorer's Initials				
TOTAL SCORE				

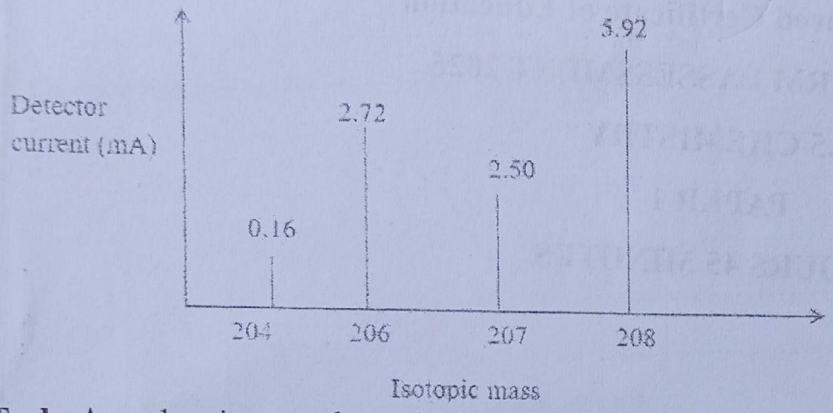
SECTION A

*Attempt **all** items from this section*

Item 1:

(a) The Uganda National bureau of standards (UNBS) received complaints about metal contamination in several imported fruit juices after consumers reported symptoms of headaches, stomach pain and dizziness. The agency suspected that the juice might contain a toxic metal but the exact metal was unknown. When the juice sample was taken and analyzed, the suspected metal in juice had mass spectrometry analysis data as shown in support material below.

During analysis the sample was ionized and then sorted into different ions which were detected.



Task; As a chemistry student with knowledge about spectrometry;

(i) Describe how the mass spectrometer **ionizes** and then **separates** the ions in order to produce the results the analytical agency could have obtained. **(05 scores)**

Ionization

Vapourized juice sample is subjected to a beam of fast moving electrons emitted by a hot filament. These electrons collide with the atoms of the vapourised sample from which 1 or 2 electrons are removed to form positive ions

$M(g) + e \longrightarrow M^+(g) + 2e$ (2½)

Separation (deflection of ions)

The positively charged ions are passed through a variable magnetic field where they are deflected according to their mass-charge ratio (i.e lighter ions are deflected more than heavier ions) and focused onto the detector, then changed into sizeable electric currents, amplified then recorded as lines as shown on the mass spectrum above. (2½)

(ii) Using the spectroscopic data presented;

- State with a reason how many isotopes the suspected metal contains. (01 score)

Four(4) Isotopes - Because four lines of varing Intensity where displayed on the mass spectrum

(1)

- Show how the relative abundance and relative atomic mass of the suspected metal can be determined. (Illustrate your answer using a calculation). (04 scores)

Relative abundance

Total Detector current = 0.16 + 2.72 + 2.50 + 5.92

= 11.3 mA

For M-204 = $\frac{0.16}{11.3}$ = 0.0142

For M-206 = $\frac{2.72}{11.3}$ = 0.2407

For M-207 = $\frac{2.50}{11.3}$ = 0.2212

For M-208 = $\frac{5.92}{11.3}$ = 0.5238

From RAM = $\sum$ (Isotopic Mass x Relative fractional abundance)

= (204 x 0.0142) + (206 x 0.2407) + (207 x 0.2212) + (208 x 0.5238)

= 207.2

04

(iii) State two reasons why mass spectrometry was the suitable method used by the agency to detect the toxic metal in the juice. (02 scores)

any two

① Very high sensitivity of mass spectrometer (Can detect substances at very low concentration) since contaminants are harmful even in tiny amounts. (1)

② High specificity (accurate identification) - since each substance gives a unique mass spectrum) (1)

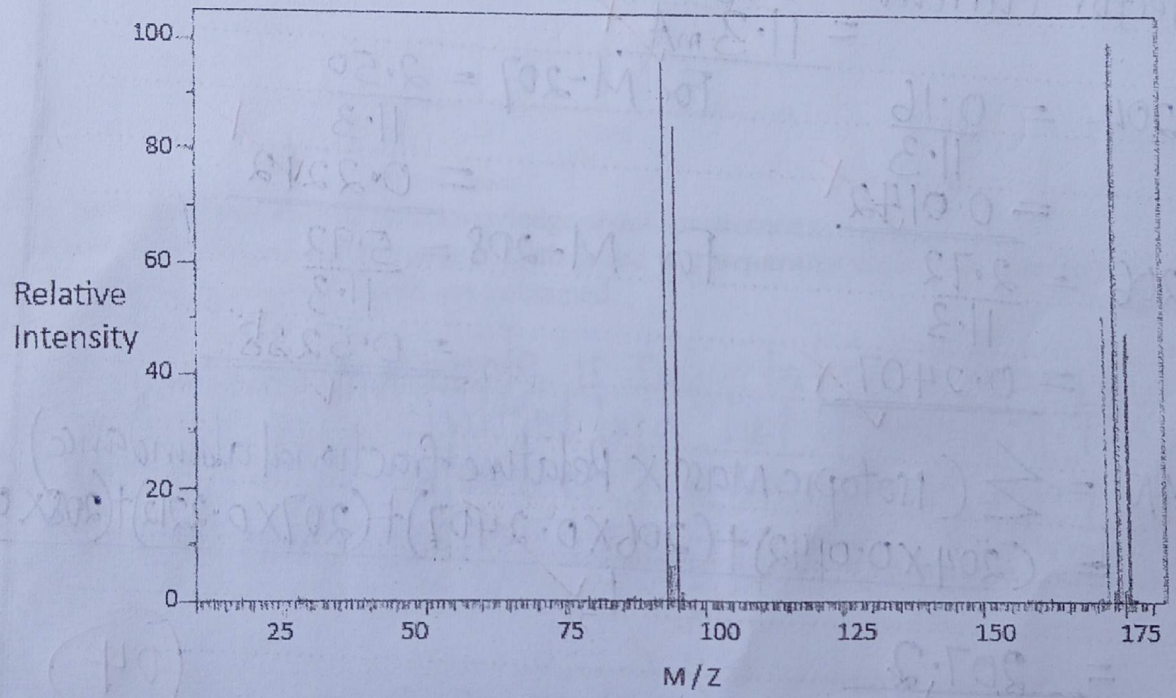
③ Detection of a wide range of contaminants

④ Quantitative analysis - can tell how much contaminant is present etc

(iv) State one advantage of using the mass spectrometer to determine the toxic metal in the juice. **(01 score)**

- It's accurate and fast to give results. (It allows early and accurate detection of tiny amounts of contaminants in the juice (1)

(b) An analysis of **dibromomethane, CH_2Br_2** using a mass spectrometer shows molecular peaks of mass-charge ratio at 79, 81, 172, 174 and 176. The relative atomic mass of bromine is 79.9. Bromine has two isotopes, Bromine-79 and bromine-81.



This information confuses Peter a new S.5 chemistry student and he needs your assistance;

Task: As a chemistry learner, guide Peter about;

(i) the species of ions responsible for the three lines at peaks 172, 174 and 176. **(03 scores)**

Molecular ions.	m/z
$^{79}Br-CH_2-{}^{79}Br^+_{(g)}$ ✓	172
$^{79}Br-CH_2-{}^{81}Br^+_{(g)}$ ✓	174
$^{81}Br-CH_2-{}^{81}Br^+_{(g)}$ ✓	176

03

(ii) how to calculate the relative percentage abundance of each bromine isotope. **(03 scores)**

Let the percentage abundance of Br-79 be a and that of Br-81 be b.

But $a + b = 100$

$a = (100 - b)$

from RAM $= \frac{\sum (\text{Isotopic mass} \times \text{relative percentage abundance})}{100}$

$79.9 = \frac{(79 \times a) + (81 \times b)}{100}$

$79.9 = \frac{79 \times (100 - b) + 81b}{100}$

$7990 = 7900 - 79b + 81b$

$90 = 2b$

$b = 45$

Thus % abundance of Br-79 is 55% and Br-81 is 45%.

03

(iii) one other special application of spectrometry in daily life. (01 score)

- Analyse blood and urine samples - Monitor Air pollution / soil contamination
- Detect diseases and Monitor drug levels in Patients - Forensic science
- Identify chemical composition of drugs - Petroleum and fuel analysis etc
- Detect harmful chemicals in lotions, soaps and creams.

any one

Item 2:

Tororo Minerals Limited has developed a new inorganic fertilizer for maize labeled **Q** in a hydrated Form. Laboratory analysis shows that the solid fertilizer contains 9.37% magnesium, 10.93% nitrogen, and 42.18% water of crystallization and rest being oxygen. Molar mass of **Q** is 256gmol^{-1}.

The fertilizer was available for sale, the manager sought to know the percentage composition of the nitrate nutrient in **Q** that would be delivered into maize. Keen to know about environmental hazards, **Q** was heated strongly and decomposed with brown gas of nitrogen dioxide according to equation:

Equation 1: $2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$

The company sought to know the volume at r.t.p of the brown gas produced from burning 0.5kg of the fertilizer and assess the environmental impacts of the emissions and mitigations.

Due to available rocks containing magnesium in the area, the company manager further seeks to evaluate the industrial synthesis of the fertilizer **Q** from magnesium oxide:

Equation 2: $MgO(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l)$

The supplier reported that he would potentially supply 15.0 kg of magnesium oxide per day, and the manager intends to know how much fertilizer would be available in one month and also possible environmental impacts of using the fertilizer and the mitigations.

Task: As a learner of chemistry, help the company know;

(a) The Molecular formula of compound **Q**. **(06 scores)**

percentage of oxygen $= 100 - (9.37 + 10.93 + 42.18)$

$= 37.52\%$

Elements/cpd	Mg	N	O	H_2O
% composition	9.37	10.93	37.52	42.18
Moles $\left(\frac{\text{Mass}}{\text{RAm/RFm}}\right)$	$\frac{9.37}{24}$	$\frac{10.93}{14}$	$\frac{37.52}{16}$	$\frac{42.18}{18}$
	0.390 moles	0.781 moles	2.345 moles	2.343 moles
Mole ratio	$\frac{0.390}{0.390}$	$\frac{0.781}{0.390}$	$\frac{2.345}{0.390}$	$\frac{2.343}{0.390}$
	1	2	6	6

E/formular is $MgN_2O_6 \cdot 6H_2O$

From $(\text{Empirical mass})_n = \text{molecular Mass}$

$(MgN_2O_6 \cdot 6H_2O)_n = 256$

$(24 \times n) + (14 \times 2 \times n) + (16 \times 6 \times n) + (6 \times 2 \times n) + (6 \times 16 \times n) = 256$ (06)

$256n = 256$

$n = 1$

Molecular formula of Q is $MgN_2O_6 \cdot 6H_2O$

(b) Percentage composition of nitrate nutrient in Q that would be delivered to maize. **(03 scores)**

Mass of Nitrate in Q $= N_2O_6$

$= 14 \times 2 + (16 \times 6)$

$= 124$

$\text{Percentage of Nitrate} = \frac{\text{mass of nitrate}}{\text{Molecular Mass of Q}} \times 100$

$= \frac{124 \times 100}{256}$ (03)

$= 48.44\%$

(c)(i) The volume at r.t.p of the brown gas produced from heating the fertilizer. **(03 scores)**

Molar Mass of $Mg(NO_3)_2 = 24 + 14 \times 2 + 16 \times 3 \times 2$

$= 148 g mol^{-1}$ (1)

148g of $Mg(NO_3)_2$ contains 1 mole
500g of $Mg(NO_3)_2$ contains $\left(\frac{1}{148} \times 500\right) = 3.3784$ moles.

2 moles of $Mg(NO_3)_2$ produces 4 moles of NO_2
3.3784 moles of $Mg(NO_3)_2$ produces $\left(\frac{4}{2} \times 3.3784\right)$
$= 6.7568$ moles of NO_2 (2½)

1 mole of NO_2 gas at r.t.p occupies $24000 cm^3$
6.7568 moles of NO_2 gas at r.t.p occupies $\left(\frac{24000}{1} \times 6.7568\right)$
$= 162,163.2 cm^3$
(or $162.1632 dm^3$ or l)

(ii) The environmental impacts of the brown gas emissions and mitigations. (02 scores)

- formation of acid rain which damages crops/acidifies soils/harms aquatic life. Formation of nitrate that causes Eutrophication leading to algal growth and oxygen depletion (02)

Mitigations – use of selective catalytic reduction system/Afforestation/Avoid open burning of waste/use catalytic converters to reduce NO_2 emission

(d) (i) Mass of the fertilizer produced in one month (04 scores)

Molar Mass of MgO = 24+16 = 40g Molar Mass of $Mg(NO_3)_2$ = 148gmol⁻¹

From the equations
40g of MgO reacts with HNO_3 to produce 148g of $Mg(NO_3)_2$
1500g of MgO reacts with HNO_3 to produce $\left(\frac{148}{40} \times 1500\right)$
$= 55,500$g of $Mg(NO_3)_2$

1 day produces 55500g of $Mg(NO_3)_2$
30 days (1 month) produces $\left(\frac{55500}{1} \times 30\right)$ (4)
$= 1665000$g or (1665 Kg) of $Mg(NO_3)_2$.

(ii) Possible environmental impacts of over using and poor management of the fertilizer.

- Eutrophication of water bodies (where excess nitrates are washed from soils into rivers and lakes causing rapid growth of algae, oxygen depletion leading to death of aquatic organisms) (02 scores)
- Water pollution
- Soil degradation (excess nitrates can alter soil pH making it more acidic, this reduces soil fertility over time) (any two) (02)
- Air pollution (Nitrate fertilizers release nitrogen oxides in air)
- Soil and water acidification (Nitrates can form nitric acid which acidifies soil and water bodies, harming aquatic organisms)