

Name:.....COMBN.....

P525/1
CHEMISTRY
Paper 1
Oct./Nov. 2025
3 hours

Uganda Advanced Certificate of Education
S5 END OF TERM 3-2025
CHEMISTRY
Paper 1
3 hours

INSTRUCTIONS:

*This paper consists **two** sections A and B*

*Section A has **two compulsory** items.*

All responses to section A must be written in the spaces provided.

*Section B has **two** parts; **I** and **II**. Respond to **only one** item from each part.*

Responses to section B should be written on answer sheets provided.

Illustrate your answers, with well balanced equations where applicable.

Where necessary, use the following:

Molar gas constant, $R=8.31 \text{ JK}^{-1}\text{mol}^{-1}$.

Molar volume of a gas at s.t.p is 22.4 litres.

Standard temperature = 273K.

Standard pressure = 101325Nm^{-2}

For Scorers' Use Only						
1	2	3	4	5	6	Total score

SECTION A

Attempt all items in this section

ITEM ONE:

A clean energy laboratory is testing a new liquid hydrocarbon fuel cell that uses a compound **Q** as the fuel. After a trial run, combustion analysis of the fuel produced 16.92 g of carbon dioxide and 3.46 g of water, while mass spectrometry revealed a relative molecular mass of 78.0 g/mol.

However, a discrepancy has arisen: the experimental enthalpy of combustion was found to be -3267 kJmol^{-1} , which differs from the value predicted/calculates using average bond energies. The research team suspects that unique bonding in the fuel molecule might be causing the discrepancy in the enthalpies of combustion.

Table 1

Bond	Bond energy(kJmol^{-1})
$C - C$	+364
$C - H$	+414
$C = C$	+256
$C = O$	+715
$O - H$	+463
$O = O$	+496.4

You have been invited to assist the laboratory team by analyzing the fuel data and providing explanations through the following tasks.

Task;

As a student with knowledge of the mole concept, thermochemistry, and chemical bonding,

- (a) Briefly explain the term **enthalpy of combustion**.

Because Strontium-90 releases heat and ionising radiation on decaying, the club must design a storage cylinder that can safely contain it. The inner lining must withstand high heat and radiation, while the outer shell should be strong, conductive, and easy to shape. Two materials are being considered: magnesium oxide and the stable metal **R** formed from the decay.

Using the data and material properties, answer the questions below, posed by your teacher and must be answered for the club to successfully embark on the project.

Task;

(a) State what happens in the nucleus when the mentioned decay process takes place. Use balanced nuclear reactions for the changes that occur above. Identify **W** and **R**.

(b) Calculate the half-life of Strontium-90 hence determine how long the waste remains hazardous. Show your working.

(d) Based on your analysis, recommend which of the materials magnesium oxide or **R** is most suitable for the storage cylinder's;
(i) the inner lining.

(ii) the outer shell.

SECTION B

Attempt only **two** items from this section, **only one** from each of the parts **I** and **II**.

PART I

ITEM 3

A chemical manufacturing company is upgrading its plant used to produce chlorine-based cleaning and bleaching agents. In the process, materials in the plant come into contact with dry chlorine gas and sodium hydroxide, both of which are highly reactive.

The company's engineers are investigating some Period 3 elements; magnesium, aluminium, silicon, phosphorus, and sulphur to identify suitable materials for high-temperature reactors and chemical-resistant surfaces.

They have found some data which is shown in **Table 2** below, that they think is useful in the journey to achieve their goal.

Table 2

Element	<i>Mg</i>	<i>Al</i>	<i>Si</i>	<i>P</i>	<i>S</i>
Melting point(K)	923	933	1687	317	388

You have been asked, as part of the student research team, to analyze this data and advise the engineers based on periodic trends.

Task;

- (a) Analyze the data above, about the melting points of the elements under investigation and explain the variations.
- (b) Justify, with reasons, which element would be most suitable for:
- a high-temperature reactor lining.
 - an alkali-resistant surface.

(c) Explain to the engineers why they may have none of the elements as a suitable choice for a high temperature reactor equipment that can get into contact with chlorine.

ITEM 4

A certain company called manufactures construction and environmental-treatment products. They are recently expanding their plant to include:

Flue-gas desulfurisation (FGD) units for removing sulfur dioxide from exhaust gases. This should be the strongest base among the compounds of their choice and most soluble in water to absorb and react with sulphur dioxide but stable at high temperatures in the absorption tower.

Thermal resistant cement additives for high-temperature furnaces, which should be a strong, heat-resistant additive to improve furnace cement used at temperatures above 1000°C but less than 1500°C.

The engineering team is evaluating some Group 2 elements and their compounds and their hydroxides or carbonates to identify which materials best suit the different industrial processes and are basing on the following data:

Table 3

Carbonate	Decomposition temperature(°C)	Hydroxide	Solubility(g/100g water (at 25°C))
$MgCO_3$	540	$Mg(OH)_2$	0.0009
$CaCO_3$	900	$Ca(OH)_2$	0.17
$SrCO_3$	1290	$Sr(OH)_2$	0.91
$BaCO_3$	1360	$Ba(OH)_2$	3.89

The company must also understand how the compounds behave during cleaning and maintenance of industrial equipment, where dilute nitric acid is commonly used.

You are part of a student research team hired to analyse the data above and link it to periodic trends, hence give advice on material selection.

Task;

- (a) Describe the reactions expected to occur during the cleaning processes.
- (b) Explain how
 - (i) thermal stability of the carbonates and;
 - (ii) solubility of hydroxides change down the group.
- (b) With reason(s), recommend a suitable compound for;
 - (i) flue-gas desulfurisation (FGD)
 - (ii) High-temperature cement additive selection.

PART II

ITEM 5

*SynthoFuel Inc.**, is a company that develops advanced fuels and industrial chemical feedstocks. The company is testing two new potential products:

Product A: A stable chemically inert blending agent for gasoline.

Product B: A highly reactive chemical to be used in polymer and plastics manufacturing.

As part of its community outreach programme, the company has partnered with your school's science department to allow students to experience how real chemical problems are solved. During this collaboration, your class is given a real industrial style problem to analyse.

The company's laboratory team has been studying a newly delivered sample of an unknown hydrocarbon, labeled as **Compound X** ($RMM=54$) **containing 88.89% carbon**.

They now invite your class to help them make sense of the data and advise on the most suitable use of the compound.

The following information is shared with you:

X reacts with 1 mole of hydrogen in the presence of a Lindlar catalyst to produce compound Y.

Y undergoes ozonolysis followed by hydrolysis to form a single product Z.

X also reacts with bromine in tetrachloromethane to form a single, colourless organic product W.

The company challenges your class to analyse the chemistry and help determine whether Compound X is suitable for Product A or Product B.

Task;

As part of the school team assisting SynthoFuel Inc., you are required to help the company;

- (a) deduce the molecular formula of X.
- (b) identify all possible isomers of X.
- (c) understand the reactions that lead to conversion of X to Y, Y to Z and X to W. (**Your answer should include the structures of the compounds involved, equations and mechanism for the conversion of X to W**)
- (d) Based on the structure and reactivity of Compound X, evaluate whether it is more suitable for use as Product A or B. Explain your choices.
- (e) Suggest one real-world application of compound;
 - (i) X
 - (ii) Y

ITEM 6

Aromatic hydrocarbons are used as solvents and precursors for industrial synthesis. One such application is manufacture of dyes and pharmaceuticals by nitration and bromination of aromatic compounds. Currently, benzene is used as the starting material but research shows that methylbenzene may act as a starting material too.

Following a recent safety audit and the introduction of new environmental regulations, schools in your district have been invited to compete in an essay competition which involves writing an article on the title; "***A comparative analysis of switching from benzene to methylbenzene for nitration reactions***".

In the article, you are tasked to help the manufacturers make a safe, efficient, and environmentally responsible choice.

Task;

- (a) Compare;
 - (i) the molecular structure and stability of the suggested starting compounds. Explain your answer.
 - (ii) their reactivity towards nitration or bromination reactions. (***Include conditions, equations and mechanisms for the reactions***)
- (b) Explain how the role of the methyl group in the reaction undergone by the two compounds in (a) above.
- (c) Identify two health hazards associated with exposure to the currently used starting compound.
- (d) Describe two potential environmental impacts of using the suggested alternative compound in industrial processes.

- (e) Based on your analysis of structure, stability, reactivity, and safety, recommend whether benzene should be continuously used or a switch to methylbenzene is necessary. ***Justify your recommendation with at least two chemical and safety reasons.***

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 Tc 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

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