Candidate's Name: ……

Signature: ……

Index Number								

UACE

Chemistry Paper 1

Theory

S.5 2025

3hours

NELSON MANDELA SECONDARY SCHOOL

Mid term III exams

S.5 Chemistry Theory paper 1

Paper 1

Theory

3 Hours

INSTRUCTIONS

- *This paper consists of five examination items in two sections A and B.*
- *Write your responses in the gaps left for section A and use the answer booklets given for responses in section B*
- *Respond to both the items in section A and two items in section B.*
- *All the items in section B carry equal scores. No any extra item attempted will be scored.*

SECTION A (42 Scores)

Item 1

A fire extinguisher manufacturing industry uses hydrocarbons as the extinguisher gas. When aimed at fire, the hydrocarbons burn to produce carbon dioxide gas which extinguishes fire. However, the liquid substance formed on burning of the hydrocarbons becomes a nuisance to the extinguishing process as it tends to boost the fire propagation. On analysis, the hydrocarbon that produces less amount of this liquid is the more suitable for this activity. Hydrocarbons J of molar mass 56 and K of molar mass 58 were analyzed to have similar carbon content but its percentage proportion by mass in the two two hydrocarbons is 85.7% and 82.8% respectively. The industrial director has totally failed to understand what the analysts tell him and so they seek help from you.

Task

a) Help the analysts to

i) Deduce the IUPAC identity of each hydrocarbon.

J. ……
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……..… 05scores

K. ……
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…… 05scores

ii) Display the structural formulae and names of each possible isomer in each hydrocarbon.

Isomers in
J. ……
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…… 02scores

K ……
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…… 02scores

b) i) Demonstrate to the director using chemical equations how each of the compounds J and K acts to extinguish the fire.

J. ……
…… 02scores

K. ……
…… 02scores

i) Basing on the stoichiometry of combustion of the two hydrocarbons, which one would more suitably be used as the extinguisher gas? (State a reason)

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…… 02scores

c) Compare the volume of carbon dioxide that is produced by each gas if a full cylinder that accommodates 500g of gas is separately used to put off fire until it is empty at s.t.p. (1mole of a gas occupies 22.4dm3 at s.t.p.)

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…… 04scores

Item 2

A certain group of boys in a school Science Club consisting of Paul Nathan and other members came across a certain greyish white metal which they suspected to be aluminium. They wanted to prove whether the metal they were expecting was right. Paul suggested heating it in steam. They heated approximately 0.52g of the metal piece in steam which produced a gas they did not know. The gas was collected, cooled and measured at room temperature. Nathan seemed unsatisfied and he suggested addition of dilute nitric acid to the solid residue that remained after heating the metal in steam. To $2cm^3$ of the resultant solution was added sodium hydroxide drop-wise until in excess, and to an other $2cm^3$ was added ammonia solution drop-wise until in excess.

The remaining solution was evaporated to complete dryness. 0.72g sample of the dry solid obtained was heated strongly until there was no further change. The students wanted to record the mass of the solid residue that remained after heating but they lacked a weighing scale to determine the accurate mass and they need your help.

Hint: ***1mole of a gas occupies $22.4dm^3$, Al=27, O=16, H=1***

Task

As a chemistry student, (supposing the metal they expected was right)

a) i) State what the boys observed and demonstrate what chemically took place when what Paul suggested was done.

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…….. 03scores

ii) Determine the volume of the volume of the gas that was collected and measured at r.t.p. (1mole of a gas occupies $24dm^3$ at s.t.p.)

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……. 02scores

b) Sate what was observed and ionically demonstrate what chemically took place when Nathan's suggestion was done after steam reaction.

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…… 03score

c) Sate what was observed and write ionic equation(s) where necessary to demonstrate the reactions that took place with excess sodium hydroxide and ammonia solutions.

i) With sodium hydroxide.

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…… 03scores

ii) With ammonia solution.

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…….. 02scores

d) i) Show what the boys would observe when the dry substance obtained after evaporation was heated strongly.

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…… 03scores

iii) Help the boys to determine the mass of the solid residue that remained after strong heating without the weighing scale.

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…… 02scores

SECTION B (58scores)

Item 3

A chemical manufacturing industry deals in the manufacture of nitric acid and supplies it to different chemical laboratories in Uganda. The production of the acid is based on Haber process where 0.3moles of nitrogen are normally reacted with 0.5moles of hydrogen.

$N_{2(g)} + H_{2(g)} \longleftrightarrow NH_{3(g)}$ $\quad \Delta H = -92KJmol^{-1}$

The amount of ammonia produced at equilibrium is normally 0.3moles. The volume of ammonia produced at s.t.p determines the amount of acid that is produced and the degree of dissociation determines the stability of the gas at equilibrium, the equilibrium constant Kc value and the position of the equilibrium. Due to the increased demand of ammonia solution and nitric acid on the market, the rate at which ammonia is produced must be increased. According to the industrial chemical analysts, if the degree of dissociation of ammonia is below 0.2, ie 20%, the reaction conditions must be altered to adjust the equilibrium value, position and the rate of production of ammonia.Among the conditions to be altered are concentration of the reactant gases, pressure and temperature in the reaction vessel. The reaction vessel can accommodate a maximum of $1dm^3$ of gaseous products. The industrial analysts also advised to introduce fine powder of iron metal into the reaction vessel as well as constant removal of ammonia from the vessel as promptly as possible. However, the industrial manager and his workers are confused of what the analysts are talking about because it seemed to be beyond their understanding and they seek for your help.

Task

As a chemistry student, Help the manager and his team to

a) Determine the volume of ammonia that is normally produced at equilibrium at s.t.p. (03scores

b) Determine the degree of dissociation of ammonia and the equilibrium constant Kc. From your results, draw a conclusion on whether to alter the conditions or not according to the advise of the analysts.
08score

c) If the conditions were to be altered; Explain with genuine reasons how the alteration of each condition would affect the production process. 09scores

d) Briefly describe the process of production of nitric acid using the ammonia obtained from this industrial process. 05scores

e) Explain the effect of introducing fine iron metal powder into the reaction vessel and the prompt removal of ammonia from the vessel. 05scores

Item 4

A Certain group of scientific innovators intends to start up a nuclear plant. The plant is intended to deal with many radioactive services including age determination of very old carbon based material in archaeological sites by carbon dating. All the parties in this project agreed to use carbon as the element of interest. On testing, 40g of carbon atoms were experimentally bombarded into a mass spectrometer. The spectrometric behavior of carbon showed three isotopes of atomic masses 12, 13 and 14 with experimental weights of 38.16g, 1.80g, and 0.04g respectively out of the 40g. Carbon isotope ^{14}C was found to be the most suitable for the dating; however, it appeared less abundant among others. It was suggested that if the most abundant isotope was fused with some radioactive particles, more of the required radioactive isotope ^{14}C could be obtained. It was also found out that the minimum amount of the radioactive isotope that can run the plant in any given sample, below which the plant reactors stop, is 0.0299g. The science group had purchased only 100g of the sample before testing. The first carbon dating experiment was performed on an old skull from Bigobyamugyenyi archaeological site, where the skull contained 2.1×10^{9} carbon ^{14}C atoms. (It is scientifically believed that a fresh human skull born contains 7.5×10^{21} carbon atoms; Half-life of carbon ^{14}C is 5730years; Atomic number of carbon is 6.)

Task

As a science student, you joined the group and you are expected to;

a) i) Determine the relative percentage abundance of each carbon isotope.04scores

ii) Determine the average relative atomic mass of carbon. 04scores

b) i) Describe how the most abundant carbon isotope would be converted to the radioactive carbon isotope in case it gets depleted according to the scientists.

ii) Find out; how long (in years) will the amount of the radioactive carbon ^{14}C in the remaining sample work before the plant reactors stop. 08scores

c) Calculate the age in years of the skull that was first tested at Bigobyamugyenyi archeological site. 04scores

d) i) How will this plant benefit the country? 02scores

ii) What are the implications of this plant to the environment? 02scores

Item 5

Anitah, a S.5 PCM class student at Nelson Mandela S.S, wants to make a project of making an electronic cell. She has two ionic salts; Potassium Iodide and Potassium Chloride, one of which she has to choose for use as the electrolyte. It is well known to her that the salt with the higher solubility in water or less stable is more suitable for use in this project. However, she is confused of which one of the two. When she consulted the chemistry teacher for advice, she was given the following enthalpy data in table 1 to use for self direction. But she failed to know how to use it and she needs your help.

Enthalpy description	Enthalpy value (KJ/mol)
Formation of potassium iodide	-327.9
Formation of Potassium Chloride	-436.7
Hydration of potassium Iodide	-628
Hydration of potassium Chloride	-685
Sublimation of potassium	89
First ionization of potassium	419
Bond dissociation of Iodine	151
First electron affinity of Iodine	-295
First electron affinity for Chlorine	-349
Bond dissociation energy of Chlorine	242.3

Task

As her fellow chemistry student, Help Anitah to;

a) Identify the more suitable electrolyte for use in her project basing on stability. State a reason for your suggested choice. 03scores

b) Explain the two factors that affect the solubility of the electrolytes. 05scores

c) Determine the lattice energy of each electrolyte she has using a suitable energy diagram. 10scores

d) Determine the enthalpy of solution for the each electrolyte. Using born haber cycles. 08scores

e) Comment on the results and recommend Anitah on which salt she should use for her project. 03score

END