PROPOSED GUIDE

Name: _____ Centre/index No____

Signature: _____

P525/1

CHEMISTRY

Paper 1

Aug. 2023

2 ¾ hours

RUKUNGIRI DISTRICT SECONDARY SCHOOLS'

JOINT MOCK EXAMINATIONS 2023

Uganda Advanced Certificate of Education

Chemistry

Paper 1

2 Hours 45 Minutes.

INSTRUCTIONS TO CANDIDATES.

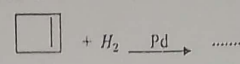
- *Answer all questions in section A and any six questions in section B.*
- *All questions must be answered in the spaces provided*
- *The periodic table, with relative atomic masses, is attached at the end of the paper.*
- *Non-programmable scientific electronic calculators may be used.*
- *Illustrate your answers with equations where applicable.*
- *Molar gas constant, R= 8.31Jk^{-1}mol^{-1}*
- *Molar volume of gas at s.t.p is 22.4 litres.*

For Examiner's Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
04½	06	05½	04	06	05	06	06	03	09	09	09	09	09	09	09	09

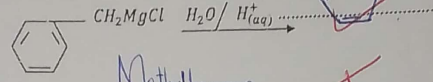
SECTION A (46 MARKS)

Answer all questions in this section.

1. Complete the following reaction equations and write I.U.P.A.C names of the main product in each case.

(a)  (01mark)

Name of product ..Cyclobutane.. (½ mark)

(b)  (01mark)

Name of product ..Methylbenzene.. (½ mark)

$CH_3C = CHCH_3$ $\xrightarrow{MnO_{4(aq)}^- / OH_{(aq)}^-}$ ..... (01mark)

Name of product ..2-Methylbutane-2,3-diol.. (0½ mark)

2. (a) When a radioactive isotope was left to stand, it decayed by $^3/_4$ of the original mass in 48 days. Calculate the half life of the radioactive isotope. (02marks)

$\ln\left(\frac{N_o}{N_t}\right) = \lambda t$ | $\ln\left(\frac{4}{3}\right) = 48\lambda$ | $t_{\frac{1}{2}} = \frac{\ln 2}{0.005993}$

$\ln\left(\frac{N_o}{\frac{3}{4}N_o}\right) = 48\lambda$ | $\lambda = 0.005993$ per day | $= 115.66$ days

$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$

(b) Complete the following nuclear reaction. (03marks)

(i) $^{233}_{91}Pa \xrightarrow{\beta}$ ..$^{233}_{92}U$..

(ii) $^1_1H \longrightarrow$ ..$^0_{+1}e$.. + ^1_0n

(iii) $^{238}_{92}U \longrightarrow$ ..$^{234}_{90}Th + \alpha + \gamma$..

(c) What is meant by stability of a nucleus. (01mark)

..Is the ability of a nucleus to resist disintegration without emitting radioactive particles and rays..

3. State the conditions and equations for the reaction between water and

(a) Magnesium. (03 ½ marks)

Conditions : Heat

$Mg_{(s)} + H_2O_{(g)} \longrightarrow MgO_{(s)} + H_{2(g)}$

Conditions : Water must be cold

$Mg_{(s)} + 2H_2O_{(l)} \longrightarrow Mg(OH)_{2(aq)} + H_{2(g)}$

(b) Chromium. (02marks)

Condition : Heat

$2Cr_{(s)} + 3H_2O_{(g)} \longrightarrow Cr_2O_{3(s)} + 3H_{2(g)}$

4. Ozonolysis and hydrolysis of alkenes gave products which on analysis were found to have the following structures.

(a) A $\xrightarrow[Zn/H_2O,\ heat]{O_3}$ $CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 + CH_3CHO$

(i) Write structural formula of A (01mark)

$CH_3CH \quad CH_3CH_2C=CHCH_3$

CH_3

(ii) Name A (01mark)

3-Methylpent-2-ene

(b) B $\xrightarrow[Zn/H_2O,\ heat]{O_3}$ $CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 + CH_3\overset{O}{\overset{\|}{C}}CH_3$

(i) Write structural formula of B (01mark)

$CH_3CH_2C(CH_3)=C(CH_3)CH_3$

(ii) Name B. (01mark)

2,3-Dimethylpent-2-ene

5. (a) When 142cm^3 of a hydrocarbon P of molecular mass 58 was exploded with oxygen and cooled to room temperature, the volume of the residue gas was 694cm^3. After addition of concentrated potassium hydroxide, the volume decreased to 126cm^3. Determine the molecular formular of P. (04marks)

$C_xH_y + (x+\frac{y}{4})O_{2(g)} \rightarrow xCO_{2(g)} + \frac{y}{2}H_2O_{(l)}$

142cm^3 of P produce $(694-126)$cm^3 of CO_2

1cm^3 of P produce $\frac{568}{142}$cm^3 of CO_2

$x = 4$

$C_4H_y = 58$

$(12\times4) + y = 58$

$y = 58-48$

$y = 10$

∴ molecular formula of P is C_4H_{10}

(b) Name compound P and state the possible isomers of P. (02marks)

P is butane ; $CH_3CH_2CH_2CH_3$; $CH_3CH(CH_3)CH_3$ 02

6. (a) Aluminium powder was added to sodium hydroxide solution.

(i) State what was observed. (01mark)

A grey solid dissolves forming a colourless solution with bubbles of a colourless gas 01

(ii) Write equation for the reaction that took place. (01½ marks)

$Al_{2}O_{3(s)} + 2Al_{(s)} + 2OH^-_{(aq)} + 6H_2O_{(l)} \rightarrow 2Al(OH)^-_{4(aq)} + 3H_{2(g)}$ 1½

(b) Sodium carbonate was added to a solution of aluminium chloride.

(i) State what was observed. (01mark)

White precipitate and bubbles/effervescence of a colourless gas 01

(ii) Write equation for the reaction that took place. (01½ marks)

$2Al^{3+}_{(aq)} + 3CO^{2-}_{3(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)_{3(s)} + 3CO_{2(g)}$ 1½

Accept: $2Al(H_2O)^{3+}_{6(aq)} + 3CO^{2-}_{3(aq)} + 3H_2O_{(l)} \rightarrow 2Al(H_2O)_3(OH)_{3(s)} + 3CO_{2(g)}$

7. Name one reagent that can be used to distinguish between each of the following pairs of compounds. In each case, state what is observed if the reagent is separately treated with each member of the pair.

(a) CH_3CH_2COOH and $HCOOH$ (03marks)

Reagent: Ammoniacal silver nitrate solution and warm

Observation: with CH_3CH_2COOH : No observable change 03

with $HCOOH$: Silver mirror deposit

(b) $CH_3CH_2CH_2OH$ and $(CH_3)_3COH$. (03marks)

Reagent: Anhydrous zinc chloride and concentrated hydrochloric acid

Observation: with $CH_3CH_2CH_2OH$: No observable change at room temperature

with $(CH_3)_3C-OH$: Cloudy solution formed immediately 03

8. (a) Methane reacts with steam according to the following equation:

$CH_{4(g)} + 2H_2O_{(g)} \rightarrow CO_{2(g)} + 4H_{2(g)}$

The enthalpies of formation of methane, water and carbon dioxide are -76, -242 and -394 KJmol^{-1} respectively. Calculate the enthalpy change for the backward reaction. (04marks)

$\Delta H^{\ominus}_R = \sum \Delta H^{\ominus}_f(\text{products}) - \sum \Delta H^{\ominus}_f(\text{reactants})$

$= (-76 + 2(-242)) - (-394 + 4(0)) = -166$ KJmol^{-1} 04

(02marks)

(b) What is meant by the term enthalpy of formation? (01mark)

Is the enthalpy change that occurs when one mole of a compound is formed from its constituent elements in their normal physical states under standard conditions.

9. Aluminium in group three of the periodic table shows some similarities with beryllium in group two of the periodic table.

(a) State two chemical properties in which aluminium and beryllium show similarities. (02marks)

Aluminium and beryllium react with hot concentrated sodium hydroxide solution.
Aluminium oxide and beryllium oxide react with hot concentrated sodium hydroxide solution.

(b) Give a reason why aluminium shows some similarities in properties with beryllium. (01marks)

They have similar Aluminium and beryllium atoms have similar atomic radius.

SECTION (54MARKS)

Answer any six questions from this section.

10. (a)(i) What is meant by the term soap as used in organic chemistry? (01mark)

Soap is a salt of sodium or potassium with a long chain carboxylic acid

(ii) Name two sources of animal fat used in manufacture of soap.

Fish
Pork

(b) Discuss the cleansing action of soap. (03marks)

Soap works by lowering the surface tension of water for dirt.
The hydrophilic / polar head of soap dissolves in the water while the hydrophobic / non-polar tail is attracted to the dirt breaking the dirt / grease into small droplets which are released in water.
During agitation with enough water, the dirt is removed from the cloth.

(c) A sample of soap was prepared from 12g of a vegetable oil containing an ester of hexadecanoic acid ($C_{15}H_{31}COOH$). Calculate the mass of soap formed. (04marks)

$CH_2OOC(CH_2)_{14}CH_3$
$CHOCO(CH_2)_{14}CH_3 (aq) + 3NaOH(aq) \rightarrow 3CH_3(CH_2)_{14}COONa(s) + CH_2CHCH_2OH$ (l)
$CH_2OCO(CH_2)_{14}CH_3$

$R_{mm\ of\ oil} = (3(14)+9)\times 12 + 6(16) + 98$
$= 612 + 96 + 98$
$= 806$

$R_{mm\ of\ soap} = 16(2) + 23 + 31 + 12(16)$
$= 278$

1 mole of oil produces 3 moles of soap

i.e 806g of oil produce (3×278)g of soap

12g of oil produce $\frac{(3 \times 278 \times 12)}{806}$ g

= 12.4147 g of soap

11. (a)(i) Write electronic configuration of iron. (½ mark)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

(ii) State the most oxidation state of iron. (½ mark)

+3

(b)Iron(III) chloride is an important reagent in distinguishing different classes of organic compounds. Sate;

(i) the classes. (01mark)

Phenol

Carboxylic acid

(ii) what is observed with the above classes. (02marks)

A purple coloration is formed with phenol while a brown solution is formed with carboxylic acids

(c) State what is observed and write equation for the reaction between;

(i) a solution of iron(II) ions and concentrated nitric acid and warm the mixture. (02marks)

observation

A green solution turns to a brown solution

equation

$2Fe^{2+}_{(aq)} + NO_3^-{}_{(aq)} + 2H^+_{(aq)} \longrightarrow 2Fe^{3+}_{(aq)} + NO_2^-{}_{(aq)} + H_2O_{(l)}$

(ii) sulphur dioxide gas and a solution of iron(III) ions . (02marks)

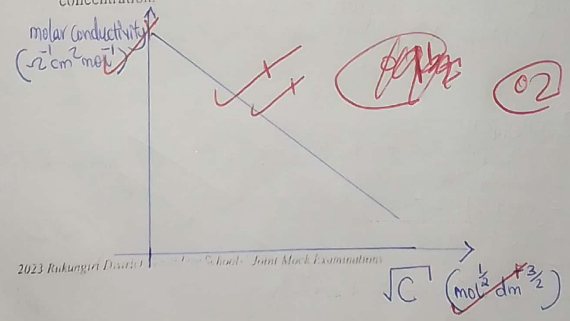
observation

A brown solution turns to a green solution

equation

$6Fe^{3+}_{(aq)} + SO_{2(g)} + 2H_2O_{(l)} \longrightarrow 6Fe^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + 4H^+_{(aq)}$

12. (a) (i) Sketch a graph of molar conductivity against square root of concentration. (02marks)



(ii)Explain the shape of your sketch graph in a(i). (03marks)

At low concentration, molar conductivity is high because the ions are far apart with less ionic interference and high ionic mobility.

Increase in concentration, decreases molar conductivity because of increase in number of conducting ions which come close to each other decreasing ionic interference but ionic mobility decreases.

(b)(i)What is meant by the term electrolytic conductivity? (01mark)

Is the conductance of an electrolyte placed between two electrodes of unit cross-sectional area separated by unit length.

(ii)A conductivity cell with resistance of 1.16Ω contains potassium chloride solution of conductivity $1.29\Omega^{-1}m^{-1}$. The second electrolyte in the same cell was found to have resistance of 15Ω. Calculate the conductivity of the second electrolyte. (03marks)

Cell constant $= R \cdot K$

$= 1.16 \times 1.29$

$= 1.4964\ m^{-1}$

$K = \frac{1.4964}{15}$

$= 0.09976\ \Omega^{-1}m^{-1}$

13 (a)(i)Describe the ~~extraction~~ manufacture of nitric acid from catalytic oxidation of ammonia. (05marks)

Ammonia gas is reacted with oxygen gas in presence of platinum catalyst to form nitrogen monoxide. $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(l)}$

Nitrogen monoxide is reacted with excess oxygen forming nitrogen dioxide gas. $2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$ (and excess oxygen)

Nitrogen dioxide is dissolved in warm water forming nitric acid. $4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \longrightarrow 4HNO_{3(aq)}$

(ii)Give one use of nitric acid. (½ mark)

Used to make explosives

(b)Concentrated nitric acid is 50% weight per weight and has a density of $1.42gcm^{-3}$. Calculate the molarity of concentrated nitric acid. (02marks)

$1cm^3$ of solution contain $1.42g$ of HNO_3

$1000cm^3$ of solution $\left(\frac{1.42 \times 1000}{1}\right) = 1420g$ of HNO_3

mass of $HNO_3 = \left(\frac{50}{100} \times 1420\right) = 710gl^{-1}$

RFM of $HNO_3 = 1 + 14 + 16(3) = 63$

63g of HNO_3 contain 1 mole

710g of HNO_3 contain $\left(\frac{710}{63}\right)$ moles

$= 11.3M$

(c)Write an equation for the reaction between ammonia and boron trichloride. (1 ½ marks)

$BCl_{3(g)} + NH_{3(g)} \longrightarrow H_3N:\rightarrow BCl_{3(g)}$

14. Complete the following equation and in each case, write the accepted mechanism for the reaction.

(a) $CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 + NaHSO_3 \longrightarrow$ $CH_3CH_2\overset{OH}{\overset{|}{C}}(CH_3)-SO_3Na$

$NaHSO_3 \longrightarrow Na^+ + HSO_3^-$

$CH_3CH_2\overset{CH_3}{\overset{|}{C}}=O \longrightarrow CH_3CH_2\overset{O}{\overset{|}{C}}(CH_3)-SO_3H \rightleftharpoons CH_3CH_2\overset{OH}{\overset{|}{C}}(CH_3)-SO_3^-$

(b) $CH_3COCl + CH_3CH_2OH \xrightarrow{\text{Pyridine}}$ $CH_3COOCH_2CH_3 + HCl$

$CH_3CH_2OH \longrightarrow CH_3CH_2\overset{H}{\overset{|}{O}}-\overset{O}{\overset{\|}{C}}(CH_3)-Cl \longrightarrow CH_3CH_2O-\overset{O}{\overset{\|}{C}}-CH_3 + Cl^-$

(c) $CH_3\underset{CH_3}{\underset{|}{C}}HCH_2OH \xrightarrow[360^\circ C]{\text{conc. } H_3PO_4}$ $CH_2=\underset{CH_3}{\underset{|}{C}}-CH_3 + H_2O$

$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$

$CH_3CHCH_2OH \xrightarrow{H^+} CH_3\overset{+}{C}HCH_3 \xrightarrow{-H_2O} CH_3\overset{+}{C}(CH_3)CH_2 \xrightarrow{\text{hydride shift}} CH_3C^+(CH_2)CH_3$

$CH_3C^+(CH_2)CH_3 \xrightarrow{-H^+} (CH_3)_2C=CH_2 + H_3PO_4$

15. (a) What is meant by the term order of reaction? (02marks)

Is the sum of powers to which the molar concentrations of reactants are raised in an experimentally determined rate equation.

(b) Various concentration of A and B were reacted at constant temperature. The table below shows the initial concentration of A and B and their initial rates for the reaction

Experiment	[A] ($moldm^{-3}$)	[B]($moldm^{-3}$)	initial rate ($moldm^{-3}s^{-1}$)
1	0.8	0.4	5.6×10^{-3}
2	0.4	0.4	1.4×10^{-3}
3	0.2	0.2	3.5×10^{-4}

(i) State the order of reaction with respect to A and B. (02marks)

The reaction is second order with respect to A.

The reaction is zero order with respect to B.

Accept 2 0

(ii) Give reasons for your answer in b(i) above. (02marks)

Doubling the concentration of A, keeping that of B constant ~~double~~ quadruples the rate of reaction

Doubling the concentration of A and B quadruples the rate of reaction

(iii) Determine the overall order of reaction. (01mark)

Overall order = 2+0 = 2

(iv) Calculate the value of the rate constant for the reaction. (02marks)

Rate = $K[A]^2$

using experiment 1, $5.6\times10^{-3} = K(0.8)^2$

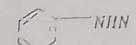
$K = \frac{5.6\times10^{-3}}{(0.8)^2} = 7.0698\times10^{-3}$ mol^{-1} dm^3 s^{-1}

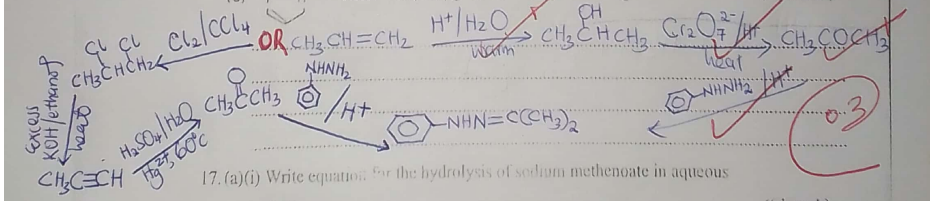
16. Write equations to show how the following compounds can be synthesized. (03marks)

(a) from 

(b) $CH_3CH_2NH_2$ from CH_3CHO (03marks)

$CH_3CHO \xrightarrow[\text{Dry ether}]{LiAlH_4} CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow{\text{Conc } NH_3} CH_3CH_2NH_2$

(c)  $NHN=C(CH_3)_2$ from $CH_3CH=CH_2$. (03marks)



17. (a)(i) Write equation for the hydrolysis of sodium methenoate in aqueous solution. (01mark)

$HCOO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HCOOH_{(aq)} + H_2O_{(l)}$

(ii) Write an expression for the hydrolysis constant, K_h of sodium methanoate. (01mark)

$K_h = \frac{[HCOOH][\bar{O}H]}{[HCOO^-]}$ 01

(b) The pH of a 0.1M aqueous sodium ethanoate solution is 8.85. calculate the hydrolysis constant of the solution. ($K_w = 1x10^{-14}\ mol^2dm^{-6}$) (04marks)

$pH = -\log_{10}[H^+]$

$= -\log_{10}(8.85)$

$8.85 = -\log_{10}[H^+]$

$[H^+] = 10^{-8.85}$

$= 1.41254\times10^{-9}\ moldm^{-3}$

But $[\bar{O}H] = \frac{K_w}{[H^+]} = \left(\frac{1\times10^{-14}}{1.41254\times10^{-9}}\right) moldm^{-3}$

$CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + \bar{O}H_{(aq)}$

$K_h = \frac{[CH_3COOH][\bar{O}H]}{[CH_3COO^-]}$

At equilibrium, $[CH_3COOH] = [\bar{O}H]$

$\Rightarrow K_h = \frac{[\bar{O}H]^2}{[CH_3COO^-]}$

$= \left(1\times10^{-14} \div 1.41254\times10^{-9}\right)^2$ 04

(c) The solubility of strontium hydroxide is 0.524g per $100cm^3$ of water at 20°C. Calculate the solubility product of strontium hydroxide at 20°C. (03marks)

RFM of $Sr(OH)_2 = 87.6 + 16(2) + 2$

$= 121.6$

121.6g of $Sr(OH)_2$ contain 1mole

0.524g of $Sr(OH)_2$ contain $\left(\frac{0.524}{121.6}\right)$ moles

$= 0.0042309$ moles

$100cm^3$ of solution contain 0.0042309 moles of $Sr(OH)_2$

$1000cm^3$ of solution contain $\left(\frac{0.0042309\times1000}{100}\right)$ moles

$= 0.042309\ moldm^{-3}$

$Sr(OH)_{2(s)} + aq \rightleftharpoons Sr^{2+}_{(aq)} + 2\bar{O}H_{(aq)}$

END

$= 5.0119\times10^{-10}\ moldm^{-3}$

$[Sr^{2+}] = 0.042309\ moldm^{-3}$

$[\bar{O}H] = (2\times0.042309)\ moldm^{-3}$

$K_{sp} = [Sr^{2+}][\bar{O}H]^2$

$= 0.042309(2\times0.042309)^2$

$= 3.0294\times10^{-4}\ mol^3dm^{-9}$ 02

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1 H 1.0																1 H 1.0	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.4	18 Ar 40.0
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.7	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98.9	44 Ru 101	45 Rh 103	46 Pd 106	47 Ag 108	48 Cd 112	49 In 115	50 Sn 119	51 Sb 122	52 Te 128	53 I 127	54 Xe 131
55 Cs 133	56 Ba 137	57 La 139	72 Hf 178	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 Tl 204	82 Pb 207	83 Bi 209	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)															

57 La 139	58 Ce 140	59 Pr 141	60 Nd 144	61 Pm (145)	62 Sm 152	63 Sm 150	64 Eu 152	65 Tb 159	66 Dy 162	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
89 Ac (227)	90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf 251	99 Es (254)	100 Fm (257)	101 Mv (256)	102 No (254)	103 Lw

1. $\overset{1}{H}$ — indicates Atomic number.

2. $\underset{1.0}{H}$ — indicates relative Atomic mass.