MARKING SCHEME

233/2
CHEMISTRY
PAPER 2
(THEORY)
JULY 2024
TIME: 2 HOURS

MUSLIM SCHOOLS JOINT EXAMINATION TEST

Kenya certificate of secondary education

1. The table below represents elements across period three of the periodic table. Study it and answer the questions that follow.

Element	Na	Mg	Al	Si	P	S	Cl
Atomic numbers	11	12	13	14	15	16	17
Atomic Radius(nm)	0.156	0.136	0.125	0.118	0.110	0.104	0.099
Ionic Radius (nm)	0.095	0.065	0.050	-	-	0.184	0.181
Melting Point(0^0c)	97.8	650	660	1410	44.2	11.9	-101

(a) (i) Explain why the atomic radius of Na is bigger than its ionic radius (2mks)

The ion is formed through losing an electron; therefore, the nuclear charge is exerted over fewer electrons in the ion than in atom // the ion has fewer energy levels; with a stronger nuclear charge.

(ii) Compare the atomic radius of Mg with that of Al
(2mks)

Al has a smaller atomic radius than Mg; Al has more protons with a stronger nuclear charge.

(iii) Explain the trend in the melting points from Na to Al (2mks)

Melting point increases; due to an increase in strength of the metallic bond brought about by an increase in number of valence electrons that are contributed to metallic lattice across the period.

(iv) Write the formula of the compound formed when Mg combines with Si.

BG_2

(1mk)

(v) Name the type of bond formed in (iv) above. (1mk)

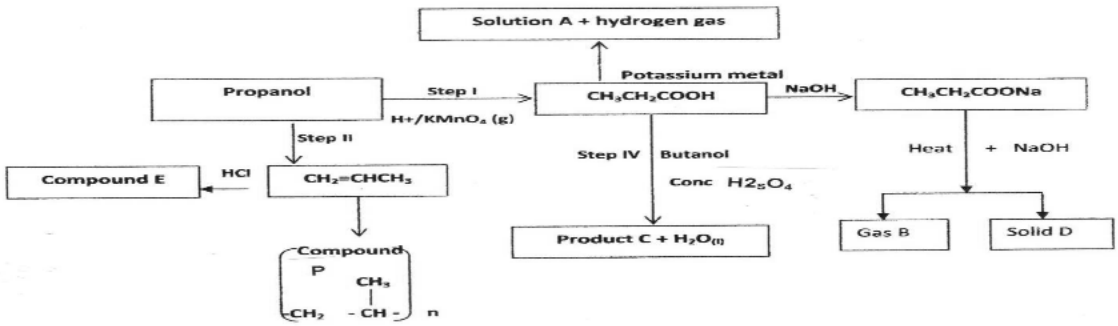
Ionic

(b) The melting and boiling points of sodium chloride are 801^0C and 1430^0C

respectively. Explain why sodium chloride does not conduct electricity at 25^0C, but does so at temperature 801^0C and 14300C.
(2mks)

At 25^0C NaCl exists as a solid; and lacks free mobile ions; but at 801 – 1430^0C, it is molten/liquid; with free and mobile ions;

2. The scheme below shows a series of reactions starting with Propanol. Study it and answer the questions that follow:-



a. Name the type of reaction in steps I and II.
Step I ***Oxidation*** (1mk) Step II ***Dehydration*** (1mk)
b. Write a balanced chemical equation for the reaction that produces:
(i) Gas B (1mk)

$$CH_3CH_2COONa(s) + NaOH(aq) \xrightarrow{heat} CH_3CH_3(s) + Na_2CO_3(s)$$

(ii) Solution A. ***$2CH_3CH_2COOH_{(l)} + 2Na_{(s)} \longrightarrow 2CH_2CH_2OONa_{(aq)} + H_{2(g)}$*** (1mk)
c. Name the substances labelled A, D and E. (3 mks)
A Sodium propanoate D Sodium hydrogen carbonate E 1-Chloropropane
d. Draw the structural formula of product C. (1mk)
$CH_3CH_2COOCH_2CH_2\ CH_2CH_3$ (should be open)

e. Name the process in Step (IV) ***Esterification*** (1mk)
f. If the relative molecular mass of P is 35,700, determine the value of n.
(C = 12, H = 1) (2mks)

$$n = \frac{35700}{42} = 850$$

3. (a) State the Hess' law. (1 mark)
The energy change in converting reactants to products is the same regardless of the route by which the chemical change occurs.

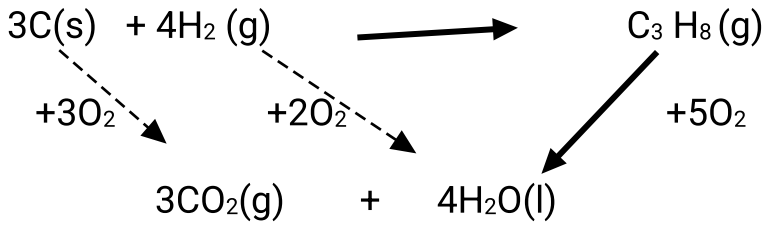
(b). Use the standard enthalpies of combustion of graphite, hydrogen and enthalpy of formation of propane to answer the questions that follow.
ΔH°combustion (carbon) = - 393kJmol-1
ΔH°combustion (H_2 (g)) = - 286kJmol-1

ΔH^{o}formation (C_3H_8 (g)) = -104 kJmol-1

(i). Write the equation for the formation of propane. (1 mark)

$C_{(s)} + H_{2(g)} \longrightarrow C_3H_{8\ (g)}$

(ii). Draw an energy cycle diagram that links the heat of formation of propane with its heat of Combustion of graphite and hydrogen. (3 marks)



(iii). Calculate the standard enthalpy of combustion of propane. (2 marks)

$\Delta H^{\theta}_{f\ C3\ H8\ (g)} + \Delta H^{\theta}_{c\ C3\ H8} = \Delta H^{\theta}_{c\ C(s)} - \Delta H^{\theta}_{c\ CO(g)}$

$-104 + (x) = (-393 \times 3) + (-286 \times 4)$

$X = -2323 + 104 = -2219\ kJmol\text{-}1$

(c). Other than the enthalpy of combustion, state one other factor which should be considered when choosing a fuel. (1 mark)

Heating value//Ease and rate of combustion//Availability//Ease of transportation//Ease of storage//Environmental effects//Cost (any one)

(e). The following data was obtained during an experiment to determine the molar heat of combustion of ethanol.

Volume of water used = 500cm³
Initial temperature of water = 25°C
Final temperature of water = 44.5°C
Mass of ethanol + lamp before burning = 121.5g
Mass of ethanol + lamp after burning = 120.0g
Calculate the

(i) Heat evolved during the experiment (density of water = 1 g/cm³, specific heat capacity of water = 4.2Jg⁻¹⁻K¹). **(1 mark)**

Heat evolved = Mass of solution × Specific heat capacity × Temperature change

$= 0.5\ kg \times 4.2\ kJ\ g^{-1}\ K^{1} \times 19.5\ k = 40.95\ kJ$

(ii) Molar heat of combustion of ethanol (C = 12, O = 16, H = 1). **(2 marks)**

$Moles\ of\ ethanol\ burned = \frac{1.5\ g}{46\ g\ mol^{-1}} = 0.03261\ moles$

0.03261 moles of ethanol liberate 40.95 kJ of heat.

$Therefore\ 1\ mol\ of\ ethanol\ will\ liberate \frac{40.95\ kJ \times 1.0\ mol}{0.03261\ mol} = -1255.8\ kJ/mole\ of\ heat$

(iii) Write the thermochemical equation for the complete combustion of ethanol. $CH_3CH_2OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2\,(g)} + 3H_2O_{(l)}$ $\Delta H = -1255.8\ kJ\ mol^{-1}$
(1 mark)

4. (a) Use the standard electrode potentials for elements **A**, **B**, **C**, **D** and **F** given below to answer the questions that follow. The letters do not represent the actual symbols of the elements.

	E^{θ}
$A^{2+}_{(aq)} + 2e \longrightarrow A_{(s)}$	$-2.90V$
$B^{2+}_{(aq)} + 2e \longrightarrow B_{(s)}$	$-2.38V$
$2C^{+}_{(aq)} + 2e \longrightarrow C_{2(g)}$	$0.00V$
$D^{2+}_{(aq)} + 2e^{-} \longrightarrow D_{(s)}$	$+0.34V$
$\frac{1}{2}F_{2(g)} + e^{-} \longrightarrow F^{-}_{(aq)}$	$+2.87V$

(i) Identify the strongest oxidizing agent. Give a reason. (2 marks)

F_2; has the highest reduction potential//Most positive e.m.f.

(ii) Which element is likely to be hydrogen? Give a reason for your answer. (2 marks)

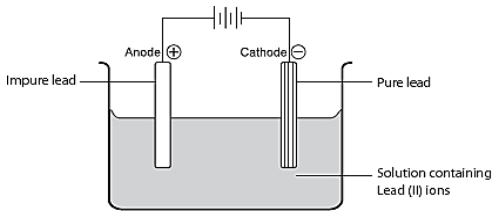
C; assigned an electrode potential of 0.00 which is reference electrode.

(iii) Identify two half-cells which when connected will produce the highest E^{θ} value. *A and F* (1 mark)

(iv) Calculate the E^{θ}value of the electrochemical cell obtained when the half-cells of elements C and D are combined. (1 mark)

$E^{\theta}_{Cell} = E^{\theta}_{R} - E^{\theta}_{o} = +2.87 - (-2.90) = +5.77\ V$

(b) Draw a fully labelled diagram to show how you can purify lead rod through electrolysis. (3 marks)



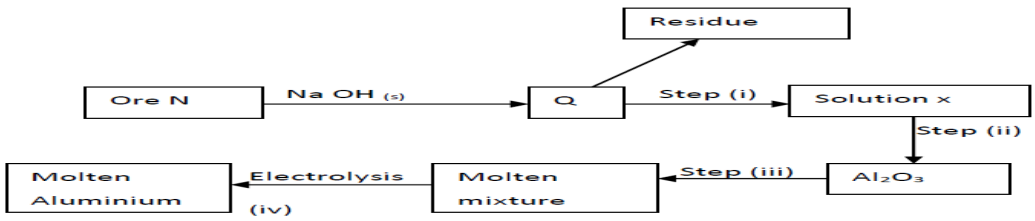
(c) During electrolysis of aqueous copper (II) sulphate 144750 coloumb of electricity were used. Calculate the mass of copper metal that was obtained. (Cu= 64, 1 Faraday = 96500 C) (2mks)

$$Mass = \frac{R.A.M \times Q}{E \times F}$$

$$Mass = \frac{64 \times 144750}{} = 48g$$

2 x 96500

5. Study the flow chart below and answer the questions that follow.



a) Name ore N **Bauxite// $Al_2O_3.2H_2O$**(1mark)

b) Explain why the ore is first dissolved in excess sodium hydroxide solution.
(1mark)
In order to form sodium aluminate and separate it from Iron III oxide that is filtered out as red mud.

c) Name the major compound present in the residue.
(1mark)
Iron (III) oxide

d) Give the formula of the aluminium compound present in solution.
$[Al(OH)_4]^-$ (1mrk)

e) i) Explain how to obtain aluminium hydroxide from solution X.

(2marks)
CO_2 as is bubbled through the filtrate to precipitate aluminium hydroxide // by seeing with pure aluminium hydroxide crystals.

ii) Write equation for reaction that takes place in (e) above.

(1mark)
$2[Al(OH)_4]^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$

$$Al(OH)_4^-(aq) \xrightarrow[Seed]{Al(OH)_3(s)} Al(OH)_3(s) + OH^-(aq)$$

iii) What is the role of cryolite in the extraction of aluminium.
(1mark)

To lower its melting point (from 2015°C to around 800°C to save on the amount of heat needed to melt it).

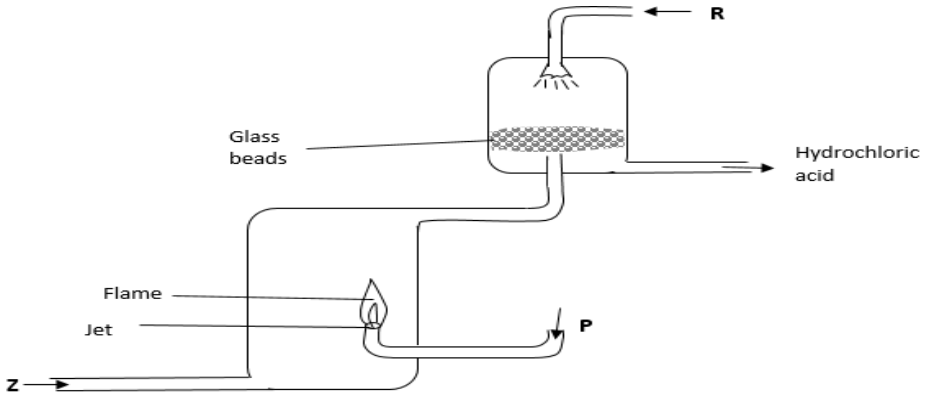
f) Aluminium is a good conductor of heat and electricity. State two uses of aluminium based on this property.
(2marks)
For making cooking vessels such as sufurias// making overhead cables

g) The melting point of alluminium oxide is 2054^0C, but electrolysis is

not carried out between 800 – 900^{0}C. Why is the electrolysis not carried out at 2054^{0}C.
(1mk)

To save on the amount of heat needed to melt it

6. The diagram below is used in the manufacture of Hydrochloric acid. Use it to answer the questions that follow:



a) Identify substances; (2 marks)

R Water // P Hydrogen

b) Why is the jet used in the set up above? (1 mark)

To control the amount of hydrogen that reacts with chlorine. (Mixture of chlorine and hydrogen reacts explosively when heated).

c) Write a chemical equation to show how substance **Z** can be prepared in laboratory. $Cl_{2\,(g)} + H_{2\,(g)} \rightarrow 2HCl_{\,(g)}$ (1 mark)

d) State **one** large-scale source of gas **P**. (1 mark)

Electrolysis of brine // Cracking of long chain alkanes

e) Nitrogen and hydrogen reacts according to the following equation at 450°c and 200 atmospheres. $N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$ $\Delta H = -92kJ$. State and explain how the yield of ammonia would be affected if the pressure is increased. (2 mks)

Yield increases; forward reaction has fewer molecules therefore equilibrium shifts to the right.

f) The half-life of sodium -20 is 8 seconds. P grams of sodium -20 decays to 3 grams in 32 seconds.

i Calculate the initial mass P, of the isotope. (2mks)

The number of half-lives $= \frac{32}{8} = 4$ $\left(\frac{1}{2}\right)^4 \times (x) = 3$

Original amount $\times \frac{1}{16}$ *= 3 = 48 g*

Alternative

$$3\text{ g} \xrightarrow[8\,s]{4^{th}\ half\text{-}life} 6\text{ g} \xrightarrow[8\,s]{3^{rd}\ half\text{-}life} 12\text{ g} \xrightarrow[8\,s]{2^{nd}\ half\text{-}life} 24\text{ g} \xrightarrow[8\,s]{1^{st}\ half\text{-}life} 48\text{ g}$$

i State one application of radioactivity in medicine. (1mk)

Used to destroy cancerous tissue // Sterilisation of surgical instruments using gamma radiation// Radioactive iodine (iodine−131) is used in patients with defective thyroid to enable doctors to follow the path of iodine through the body// Used to monitor growth in bones and healing of fractures// for providing power in heart pace setters.

g) Study the information in the table below and answer the question that follows.

SALT	SOLUBILITY (g/100g of H_2O) at	
	45 ^{0}C	60 ^{0}C
Sodium carbonate	35	80
Lead (II) Nitrate	77	101

A mixture containing 70g of sodium carbonate and 72g of lead II nitrate in 100g of water at 60 ^{0}C was cooled to 45 ^{0}C.

i Identify the salt that crystallized out. (1mk)

Sodium carbonate

i Calculate the mass of the salt that crystallized out. (2 mks)

= 70 − 35 = 35 g.

7. An impure solid copper (II) carbonate weighing 10.8g was placed in a beaker containing 50 cm^3 of dilute nitric (V) acid. The volume of carbon (IV) oxide produced was recorded after every 20 seconds and tabulated as follows.

Time (s)	0	20	40	60	80	100	120
Volume of CO_2 at S.T.P (cm^3)	0.0	650	900	1070	1100	1120	1120

On the grid provided, plot a graph of volume of carbon (IV) oxide produced against time

(3 marks)

a) Using the graph, calculate:

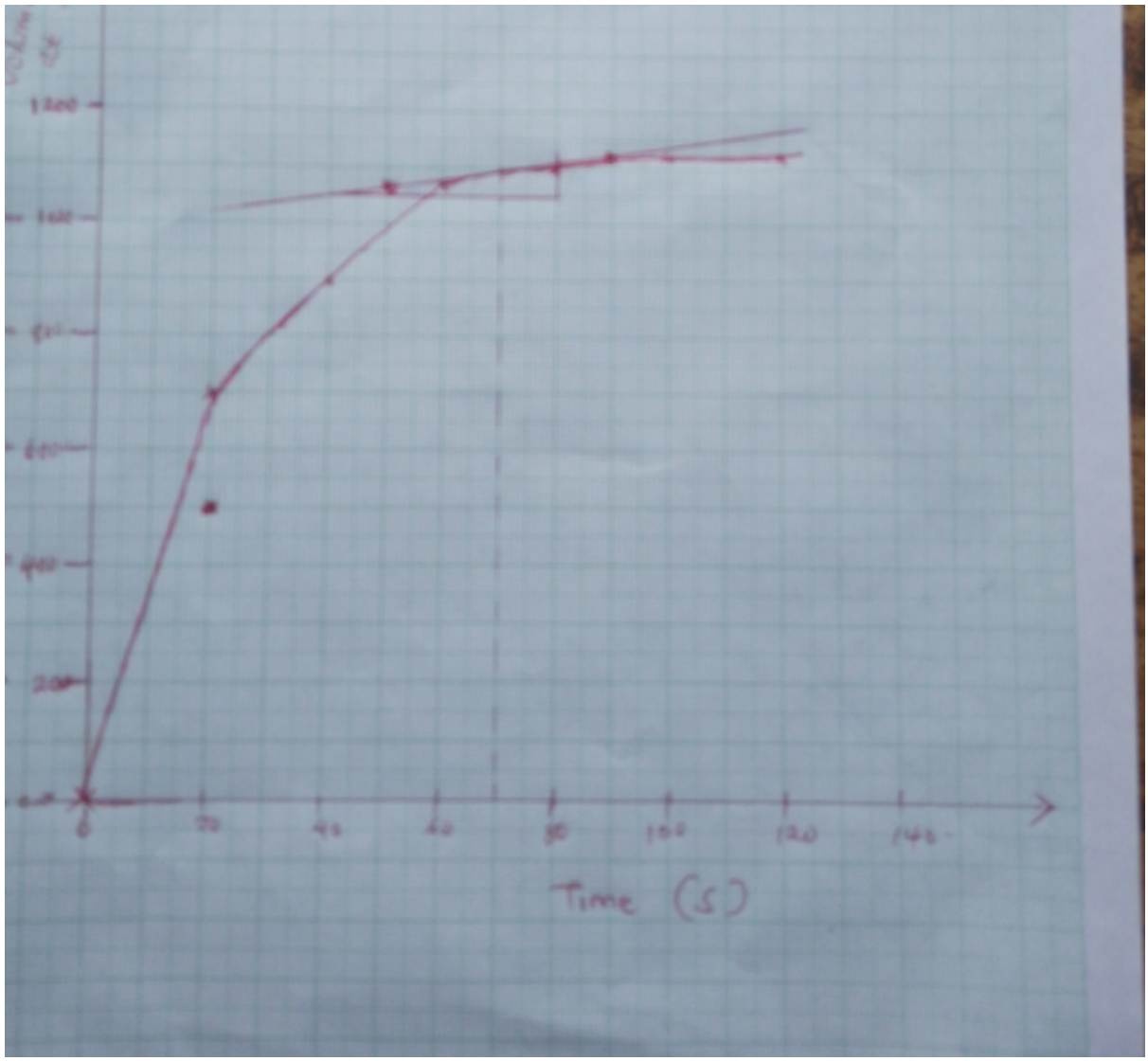
i) The rate of reaction between 20 and 40 seconds (2 marks)

$$\frac{(V_2\text{-}V\neg_1)\ cm^3}{(t_2\text{-}t_1)\ sec} = \frac{900\text{-}650\ cm^3}{40\text{-}20\ sec} = 12.5\ cm^3/s$$

ii) The rate of reaction at the 70th second (2 marks)

$$\frac{(V_2\text{-}V\neg_1)\ cm^3}{(t_2\text{-}t_1)\ sec} = \frac{1100\text{-}1050\ cm^3}{80\text{-}40\ sec} = 1.25\ cm^3/s$$ *(Tangent must be drawn to*

score)



b) Explain the trend in the rate of reaction as the reaction progresses. (1 marks)

Rate decreases: concentration of reactants decreases reducing rate of collision of particles

c) Why was there no increase in volume of the gas produced after 100 seconds?

(1 marks)

Reaction is complete// All reactants use up// No more colliding particles

d) How many moles of carbon (IV) oxide were in the maximum volume produced from this reaction? (M.G.V at s.t.p = 22400 cm^3) (1 mark)

$$\text{Moles } CO_2 = \frac{1120}{24000} = 0.005 \text{moles}$$

e) What mass of copper (II) carbonate will have reacted with the acid after 100 seconds? (Cu=64 C=12 O=16) (2 marks)

Mole ratio $CuCO_3$: CO_2 =1:1. Moles $CuCO_3$: CO_2=0.005moles

Mass $CuCO_3$= 124 x 0.005 = 6.2g