THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

CHEM

(T

233/2

Paper 2

CHEMISTRY

(Theory)

Mar. 2022 – 2 hours

C1

Name _____ Index Number _____

Candidate's Signature _____ Date _____

Instructions to candidates

(a) Write your name and index number in the spaces provided above
(b) Sign and write the date of examination in the spaces provided above
(c) Answer all the questions in the spaces provided in the question paper
(d) Non-programmable silent electronic calculators and KNEC mathematical tables may be used
(e) All working must be clearly shown where necessary.
(f) **This paper consists of 16 printed pages.**
(g) **Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**
(h) **Candidates should answer the questions in English.**

For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	11	
2	11	
3	11	
4	11	
5	15	
6	11	
7	12	
Total Score	80	

(a) **Table 1** gives the properties of two compounds, A and B.

Table 1

A	B
white, crystalline, efflorescent	white, crystalline, deliquescent

State and explain the observation made when each of the compounds is left exposed to air.

(i) Compound A (2 marks)

changes from crystalline to a powder. ✓1

forms water of crystallisation ✓1

(ii) Compound B (2 marks)

forms a white ✓1

solution when vapour from atmosphere is absorbed. ✓1

(b) In an experiment to determine the formula of hydrated magnesium sulphate, a sample was heated in a crucible until a constant mass was obtained. The results are shown in **Table 2**.

Table 2

Mass of crucible	25.62 g
Mass of crucible + solid before heating	28.09 g
Mass of crucible + solid after heating	26.82 g

Using the information in **Table 2**, determine the formula of the hydrated salt.
(Mg = 24.0; S = 32.0; O = 16.0; H = 1.0) (3 marks)

	$MgSO_4$	H_2O
Mass(g)	1.20	1.26 ✓
Moles	$\frac{1.20}{120}$ = 0.01	$\frac{1.26}{18}$ = 0.07 ✓
	$\frac{0.01}{0.01}$ = 1	$\frac{0.07}{0.01}$ = 7 ✓
	1	7

$MgSO_4 \cdot 7H_2O$ ✓

(c) **Figure 1** shows analysis of an alloy containing two metals.

Figure 1

(i) Give the name of another product formed in step 1. (1 mark)

Hydrogen gas, H_2 ✓

(ii) Write the formula of the complex ion present in the colourless solution obtained in step 2. (1 mark)

$[Zn(OH)_4]^{2-}$ ✓

(iii) Identify the metals in the alloy. (2 marks)

Zn ✓

Cu ✓

1. The flow chart in Figure 1 shows the processes involved in the manufacture of sulphuric(VI) acid.

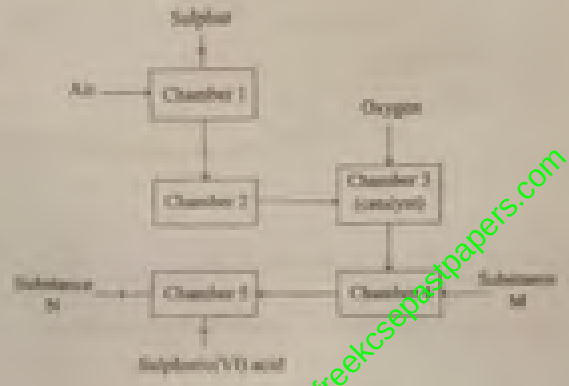


Figure 1

(a) Explain how the sulphur used in this process is obtained. (2 marks)

Through Frasch process in which superheated water pumped through concentric pipes to melt sulphur. Hot compressed air is forced through the inner pipe. It finds molten sulphur through the middle pipe to the surface.

(b) Give one advantage of using air in chamber 1 instead of using oxygen gas. (1 mark)

Air is cheap/economical/available

(c) Identify substances:

(i) M (1 mark)

H_2SO_4 (l) ✓1

(ii) N (1 mark)

H_2O ✓1

(d) (i) In chamber 2, drying and purification take place. Give a reason why this is necessary. (1 mark)

Impurities in the gas poison the catalyst ✓1

(ii) The reaction in chamber 3 is highly exothermic.

I. Explain why high temperature is required for the reaction in chamber 3. (1 mark)

to increase the rate of the rxn ✓½ as the particles gain K.E. to increase collisions / frequent collisions. ✓½

II. State how the heat produced in chamber 3 can be utilised in this process. (1 mark)

Recycled to pre heat ✓1 SO_2 and O_2 gases.

(e) Give a reason why this method of manufactory is known as 'contact process'. (1 mark)

The formation of SO_3 in chamber 3 occurs when SO_2 and O_2 come into contact with each other on the surface of the catalyst.

(f) Emission of gases in the sulphuric(VI) acid plant may lead to environmental pollution.

(i) State the evidence that could be used to show that the sulphuric(VI) acid plant causes pollution. (1 mark)

Corrosion of structures / vegetation drying up / stone building structures wearing

(ii) Explain how the pollution identified in 2(f)(i) can be controlled. (1 mark)

scrubbing the gases through $NaOH$, SiO_2 [illegible]
Recycling unused gases.

5. (a) Chemical reactions occur as a result of collisions of particles. Give a reason why not all collisions are effective. (1 mark)

Colliding particles may not possess minimum [illegible] activation energy.
Particles may not collide in the right orientation

(b) State and explain how the following factors affect the rate of reaction:

(i) Surface area of reactants. (1 mark)

Increase in the surface area increases rate of reaction because more particles are exposed [illegible] [illegible] effective [illegible] collisions.

(ii) Pressure. (1 mark)

Increase in pressure brings the particles of gaseous reactants closer to each other increases collisions increasing rate of reaction [illegible] [illegible] of [illegible]

(c) In an experiment to determine the rate of a reaction, marble chips were added to excess 2M hydrochloric acid. The equation for the reaction is:

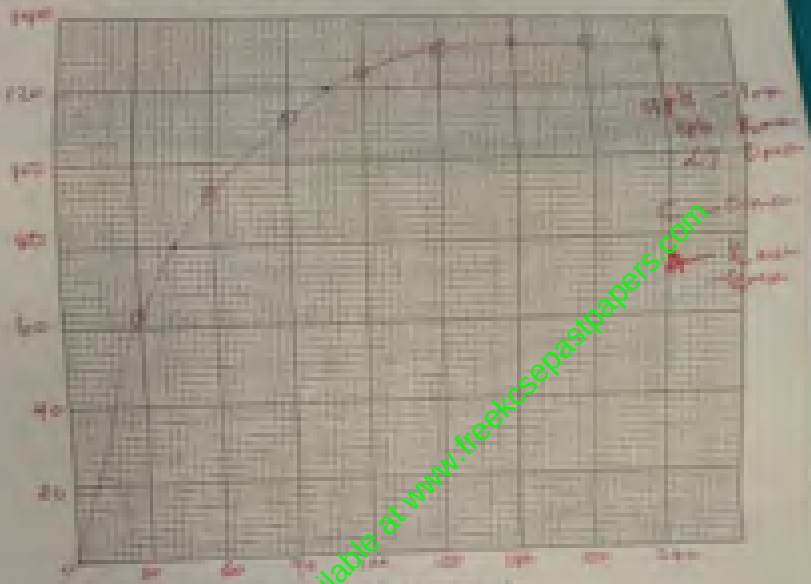
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The volume of carbon(IV) oxide produced was measured at 25 °C and recorded after every 30 seconds. Table 3 shows the results obtained.

Table 3

Time (seconds)	0	30	60	90	120	150	180	210	240
Volume of CO_2 (cm^3)	0	62	92	115	124	130	132	133	133

(c) On the grid provided, give a graph of volume of carbon(IV) oxide (vertical axis) against time (horizontal axis). (3 marks)



(d) Using the graph, determine the rate of reaction at the:

I. 45th second (3 marks)

gradient = height ✓½
gradient = height ✓½

II. 105th second (3 marks)

height ✓½
gradient = height ✓½

(iii) Give a reason for the differences in the two rates. (1 mark)

At 100th second the concentration of acid & mass of marble chips is less than at [illegible] second causing reduction in rate of [illegible] [illegible] is higher at [illegible] than 100th. [illegible]

(iv) Using the graph, determine the mass of marble chips that reacted. (2 marks)

(Ca = 40.0; C = 12.0; O = 16.0)

Molar gas volume at room temperature and pressure = 24000 cm³).

[illegible]

[illegible]

[illegible]

4. (a) Sea water contains approximately 3% sodium chloride. Describe how sodium chloride is obtained from sea water. (3 marks)

Put sea water in a beaker and boil (heat) [illegible] evaporate to get a saturated solution. Allow the soln. to [illegible] crystals are formed.

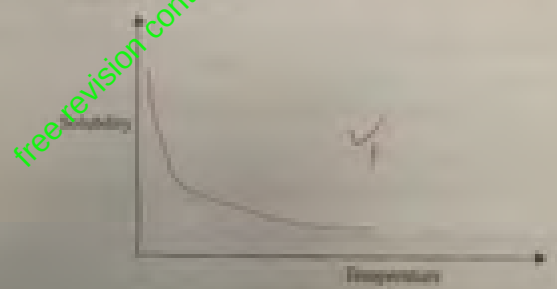
Sea water is trapped in a shallow [illegible] [illegible] [illegible] evaporation until the solid crystallises out, the [illegible] is [illegible] and [illegible]

(b) The solubility of sodium chloride is 36.2 g in 100 g of water at room temperature. Determine the concentration in moles per litre of a saturated aqueous sodium chloride at room temperature (Na = 23.0; Cl = 35.5; density of water = 1.0 gcm^{-3}). (2 marks)

(c) Ammonia is highly soluble in water

(i) Explain how aqueous ammonia is prepared starting with ammonia gas. (2 marks)

(ii) On the axes provided, sketch a curve showing how solubility of ammonia gas varies with temperature. (1 mark)



(iii) Give a reason for the shape of the curve. (1 mark)

Solubility decreases with increase in temperature because the gaseous particles gain energy and escape from solution.

(d) Water hardness is due to the presence of magnesium and calcium ions. Explain how these ions get into sources of water. (2 marks)

CO_2 dissolves in water to form carbonic acid. The acid reacts with the carbonates of Mg or Ca in the rocks. The water contains Ca^{2+} and Mg^{2+}.

5. (a) Figure 3 shows part of a Periodic Table.

								He
Li	Be				N	O	F	Ne
Na	Mg		Al	Si			Cl	Ar
K	Ca						Br	
Rb							I	
Cs								

Figure 3

(i) Select from the table the most reactive:

I metal. (½ mark)

Cs

II non-metal. (½ mark)

F

(ii) Select an element with the highest first ionisation energy. (1 mark)

He

i. Name the method used to obtain argon from its source (1 mark)

ii. Give one industrial use of argon (1 mark)

(iv) Explain each of the following observations

1 The melting point of lithium is higher than that of potassium. (1 mark)

2. The melting point of chlorine is ... that of iodine (1 mark)

The following ions have the same number of electrons: N^{3-}, Mg^{2+}, O^{2-}, Na^{+}

Arrange them in order of increasing ionic size. Give a reason for the ... (2 marks)

(b) Use **Table 4** to answer the questions that follow.

Table 4

Property	Substance			
	H	I	J	K
Melting point (°C)	993	113	−38.9	−85
Boiling point (°C)	1695	183	357	−60
Electrical conductivity at room temperature	Does not conduct	Does not conduct	Conducts	Does not conduct
Electrical conductivity in molten state	Conducts	Does not conduct	Conducts	Does not conduct

(i) Identify the substance which is a gas at room temperature.

Give a reason. (1 mark)

K Bp below room temperature

(ii) Name the particles responsible for electrical conductivity in substance:

I. H (1 mark)

ions

II. J (1 mark)

electrons

(iii) Identify the type of forces that hold the particles together in:

I. H (1 mark)

Electrostatic forces / ionic bond / electrovalent.

II. K (1 mark)

Weak van der waals forces / intermolecular

4. **Figure 4** shows a flow chart involving reactions of some organic compounds.

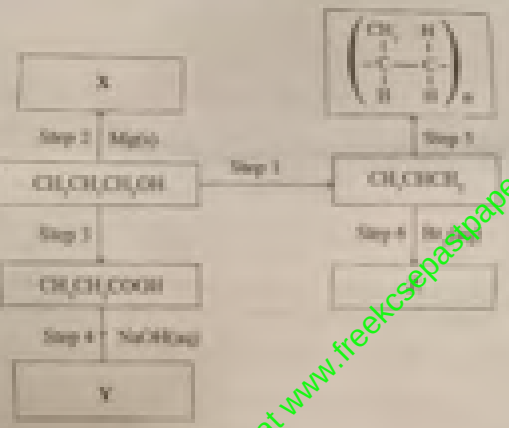


Figure 4

(a) Write the formula and give the names of compounds

(i) **X**

Name	Formula	(2 marks)
Magnesium propanoate	$(CH_3CH_2CO_2)_2Mg$	

(ii) **Y**

Name	Formula	(2 marks)
Sodium propanoate	CH_3CH_2COONa	

(b) Give the reagents and conditions necessary for carrying out:

(i) Step 3. (1 mark)

$KMnO_4$ / acidified $K_2Cr_2O_7$

Heat / warm / high temperature

(ii) Step 5. (1 mark)

Propene

catalyst (Ziegler Natta) High temperature / high pressure

(c) Step 1 can be carried out using concentrated sulphuric (VI) acid and heat. Name another reagent and conditions that can be used to carry out step 1. (1 mark)

Al_2O_3 (Alumina) / H_3PO_4

heat / high temp

(d) Give the name of the type of reaction that takes place in:

(i) Step 1. (1 mark)

Dehydration ✓

(ii) Step 5. (1 mark)

Polymerisation ✓

(e) (i) Write an equation for the reaction in step 6. (1 mark)

$CH_3CHCH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$

(ii) State the observations made in step 6. (1 mark)

Brown/orange bromine turns colourless

(a) (ii) Using the oxidation numbers of chlorine, explain why the following is a redox reaction

$$HCl(aq) + NaClO(aq) \rightarrow NaCl(aq) + H_2O(l)$$ (2 marks)

(b) Use the following standard reduction potentials to answer the questions that follow.

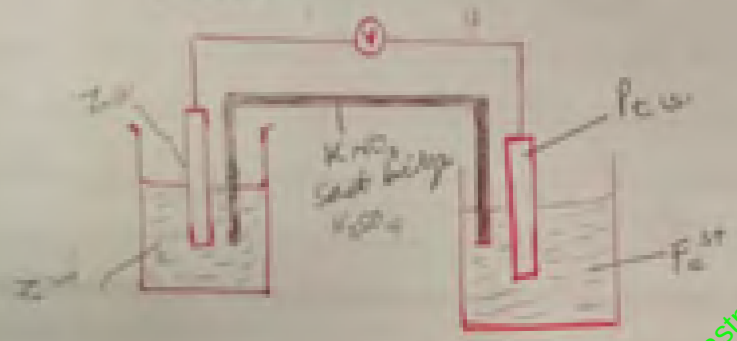
	Half cell reactions	$E^{\ominus}$/V
I	$PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$	-0.36
II	$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$	+1.69
III	$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
IV	$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76
V	$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.51
VI	$O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O_2(aq)$	+0.68
VII	$Br^-(aq) + 2e^- \rightarrow$ [illegible]	-0.44
VIII	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34

(i) The half cells I and II are combined to form an electrochemical cell.

I Write an equation for the cell reaction. (1 mark)

II Calculate the e.m.f of the cell. (1 mark)

(ii) Draw a labelled diagram for the electrochemical cell formed using half cells III and IV. (3 marks)



(iii) State and explain the observations made when a few drops of acidified potassium manganate(VII) are added to hydrogen peroxide. (3 marks)

Purple colour turns colourless. MnO_4^- is reduced to Mn^{2+}.

Bubbles of gas evolved. Oxygen gas.

(iv) Coating iron with zinc is a more effective way of corrosion prevention than coating it with copper. Explain. (2 marks)

Zinc is more reactive than iron.

Iron is more reactive than copper.