THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

032/2 **CHEMISTRY 2**

ALTERNATIVE TO PRACTICAL

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2014**

Instructions

1. This paper consists of five questions. Answer all questions.

2. Each question carries 10 marks

1. Study the following experimental set up (Figure 1) for the laboratory preparation of hydrogen chloride gas and then answer the questions that follow.

(a)(i) Name the apparatuses represented by the letters A, B, C, and D and state the use of each.

A – Round-bottom flask, used for holding the reactants (sodium chloride and concentrated sulfuric acid) where the reaction takes place.
B – Thistle funnel, used for adding concentrated sulfuric acid to the flask in a controlled manner.
C – Delivery tube, used to transfer the hydrogen chloride gas produced to the collection apparatus.
D – Water trough, used to contain water for gas collection by downward delivery.

(ii) Which part of the set up is not correct for the above experiment? Give reason for your answer.

The use of water in the trough (D) is incorrect because hydrogen chloride gas is highly soluble in water. Instead, the gas should be collected by upward delivery or over concentrated sulfuric acid, which acts as a drying agent.

(b)(i) Write a balanced chemical equation for the reaction in A.

$NaCl(s) + H_2SO_4(l) \text{ ----> } NaHSO_4(s) + HCl(g)$

(ii) State the function of sulfuric acid in the apparatus C.

Concentrated sulfuric acid acts as a dehydrating agent to dry the hydrogen chloride gas before it is collected.

(c)(i) What is the chemical test of the hydrogen chloride gas prepared in the above experiment?

When hydrogen chloride gas is exposed to ammonia gas, white fumes of ammonium chloride (NH_4Cl) are formed.

(ii) State two physical properties of hydrogen chloride gas.

Hydrogen chloride gas is highly soluble in water.
It is denser than air and can be collected by downward delivery.

2. In a certain experiment, solution AA was prepared by dissolving 4.2 g of Na_2CO_3 in 0.5 dm^3 of water. The solution was titrated against solution BB of 0.2 M nitric acid. The results were tabulated as shown in Table 1.

Table 1

Titration	Pilot	1	2	3
Final reading (cm^3)	12.50	22.50	32.40	27.60
Initial reading (cm^3)	0.00	10.00	20.00	15.00
Titre volume (cm^3)	12.50	12.50	12.40	12.60

(a) Complete Table 1.

(b)(i) Name an apparatus which is suitable for measuring nitric acid.

A burette is suitable for measuring nitric acid accurately.

(ii) Calculate the average volume of solution BB.

Average volume = (12.50 + 12.40 + 12.60) / 3 = 12.50 cm^3

(c) If the reaction in the experiment gives a mole ratio of 1:1 for the reactants, calculate:

(i) The concentration of solution AA in g/dm^3.

Moles of Na_2CO_3 in 0.5 dm^3:
Molar mass of Na_2CO_3 = 23 × 2 + 12 + 16 × 3 = 106 g/mol
Moles of Na_2CO_3 = 4.2 g / 106 g/mol = 0.0396 moles
Concentration = 0.0396 moles / 0.5 dm^3 = 0.0792 M
Concentration in g/dm^3 = 0.0792 × 106 = 8.4 g/dm^3

(ii) The molar mass of AA.

Molar mass of Na_2CO_3 = 106 g/mol

(iii) The atomic mass of element X.

Since X is sodium (Na), its atomic mass is 23.

(d)(i) Name element X in Na_2CO_3.

Element X is sodium (Na).

(ii) Write a balanced chemical equation for the reaction between solutions AA and BB.

$Na_2CO_3(aq) + 2HNO_3(aq) \text{ ---> } 2NaNO_3(aq) + CO_2(g) + H_2O(l)$

(iii) State one indicator which would be suitable in the titration, and give a reason for your answer.

Methyl orange is suitable because it changes color at the equivalence point of a reaction between a strong acid (nitric acid) and a weak base (sodium carbonate).

3. An electric current was passed through dilute copper (II) sulfate and silver nitrate voltameters which were connected in series. In each voltameter, carbon rods were used as electrodes.

(a) (i) Which cations were discharged at the cathode electrodes in each voltameter? Give reason(s).
In the copper (II) sulfate voltameter, Cu^{2+} ions were discharged at the cathode because copper is less reactive than hydrogen and preferentially deposits.
In the silver nitrate voltameter, Ag^{+} ions were discharged because silver has a higher electrode potential than hydrogen, making it more easily reduced.

(ii) Name the gas produced at one of the electrodes in each voltameter.
Oxygen gas (O_2) is produced at the anode in both voltameters due to the oxidation of water.

(iii) At which electrode was the gas produced?
The gas was produced at the anode in both voltameters.

(b) A metal coating was formed on one of the electrodes in each voltameter. Write ionic equations to show the discharging process which resulted into the metal coating in each voltameter.
Copper (II) sulfate voltameter:
$Cu^{2+}(aq) + 2e^{-} \text{ ----> } Cu(s)$

Silver nitrate voltameter:
$Ag^{+}(aq) + e^{-} \text{ ------> } Ag(s)$

(c) If 2.0 amperes were passed through the voltameters for 4.0 minutes, calculate:

(i) The mass of silver deposited.

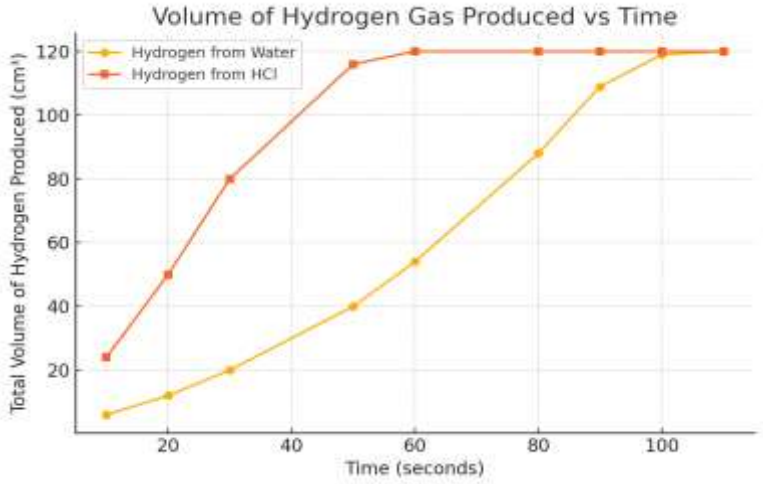
Charge (Q) = It = 2.0 A × (4.0 × 60) s = 480 C
Moles of electrons = 480 C / 96500 C/mol = 0.00497 moles
Moles of Ag deposited = 0.00497 moles (since Ag^{+} requires one electron)
Mass of Ag = 0.00497 × 108 = 0.537 g

(ii) The number of moles of each metal deposited.

Moles of Cu deposited:
Cu^{2+} requires 2 electrons, so moles of Cu = 0.00497 / 2 = 0.002485 moles

Moles of Ag deposited:
Ag^{+} requires 1 electron, so moles of Ag = 0.00497 moles

4. (a) Plot on the same axes a graph of volume of hydrogen gas produced against time for each experiment.



(b) Use your graph to predict the volumes of hydrogen gas produced in each experiment after:

(i) 40 seconds.
From the graph:
Hydrogen produced using water ≈ 30 cm^3
Hydrogen produced using HCl ≈ 100 cm^3

(ii) 70 seconds.
From the graph:
Hydrogen produced using water ≈ 80 cm^3
Hydrogen produced using HCl ≈ 120 cm^3

(c) Which reaction was more rapid at the beginning of the experiment?

The reaction of calcium with hydrochloric acid was more rapid at the beginning since it produced more hydrogen gas in a shorter period compared to calcium with water.

(d) At what time were the rates of both reactions the same?

From the graph, the rates were the same at approximately 60 seconds when both reactions reached a similar hydrogen gas volume increase rate.

(e) Write balanced chemical equations of the reactions for the two experiments.

Reaction with water:
$Ca(s) + 2H_2O(l) \text{ --- > } Ca(OH)_2(aq) + H_2(g)$

Reaction with hydrochloric acid:
$Ca(s) + 2HCl(aq) \text{ ---> } CaCl_2(aq) + H_2(g)$

5. Sample M contained one cation and one anion. Several tests were performed on the sample. The test procedures and the observations made were recorded as shown in Table 3. Fill in the inferences column; identify the ions present in sample M and hence write the chemical formula of sample M.

Table 3

Experiment	Observation	Inference
(a) Appearance of sample M.	White deliquescent solid.	Sample M is a highly soluble salt that absorbs moisture from the air.
(b) A little amount of sample M was dissolved in distilled water.	Sample M dissolved in distilled water to form a colourless solution.	Sample M is a soluble ionic compound with colourless ions.
(c) A little amount of dry sample M was heated in a test tube.	A reddish brown gas evolved. The residue was brown when hot and turned yellow on cooling. It was formed with decrepitating sound.	Presence of nitrate (NO_3^-) ions, as brown nitrogen dioxide (NO_2) gas is evolved.
(d) A trace of sample M on the tip of a nichrome wire was placed in a non-luminous flame during the flame test.	Bluish flame was formed.	Presence of Cu^{2+} ions, as copper compounds produce a blue-green flame.
(e) To a portion of solution M, a freshly prepared ferrous sulfate solution ($FeSO_4$) was added followed by concentrated sulfuric acid along the sides of the test tube.	A brown ring between the two layers was formed.	Presence of nitrate (NO_3^-) ions confirmed by the brown ring test.
(f) To a portion of solution M, ammonium hydroxide (NH_4OH) solution was added dropwise, then in excess.	White precipitate insoluble in excess.	Presence of Cu^{2+} ions, as $Cu(OH)_2$ forms a white precipitate that does not dissolve in excess NH_4OH.

Conclusion

(i) The cation in sample M was Cu^{2+} and the anion was NO_3^-.

(ii) The chemical formula of sample M is $Cu(NO_3)_2$.

(iii) Write a balanced chemical equation for the reaction taking place in experiment (f).
$Cu^{2+}(aq) + 2NH_4OH(aq) \rightarrow Cu(OH)_2(s) + 2NH_4^+(aq)$