THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3A **CHEMISTRY 3A**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2021**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:
U1: A solution containing hydrochloric acid and acetic acid
U2: 0.1 M sodium hydroxide solution
POP: Phenolphthalein indicator
MO: Methyl orange indicator

Table 1: Table of results (assumed standard titres for accurate calculations)

Burette Reading	Pilot	1	2	3	Average
Final reading (MO)	21.8	21.6	21.7	21.5	21.6
Final reading (POP)	14.4	14.2	14.3	14.1	14.2
Initial reading	0.0	0.0	0.0	0.0	-
Volume used (MO)	21.8	21.6	21.7	21.5	21.6
Volume used (POP)	14.4	14.2	14.3	14.1	14.2

Summary
(i) The volume of the pipette used was 25 cm^3
(ii) 25 cm^3 of U1 required 21.6 cm^3 of U2 when MO was used, and 14.2 cm^3 of U2 when POP was used

Questions

(a) Calculate the concentration of the acid solution, U1, in g/dm^3 when:

(i) POP was used (for strong acid, HCl):
Volume of U2 = 14.2 cm^3 = 0.0142 dm^3
Moles of NaOH = 0.1 × 0.0142 = 0.00142 mol
HCl + NaOH -----> NaCl + H_2O (1:1)
Moles of HCl in 25 cm^3 = 0.00142 mol
In 1 dm^3: 0.00142 × 1000 ÷ 25 = 0.0568 mol
Mass = 0.0568 × 36.5 = 2.0752 g/dm^3

(ii) MO was used (for total acid: HCl + CH_3COOH):
Volume of U2 = 21.6 cm^3 = 0.0216 dm^3
Moles of NaOH = 0.1 × 0.0216 = 0.00216 mol
Moles of total acid in 25 cm^3 = 0.00216 mol
In 1 dm^3 = 0.00216 × 1000 ÷ 25 = 0.0864 mol
Assume 0.0568 mol is HCl, then CH_3COOH = 0.0296 mol
Mass = 0.0568 × 36.5 + 0.0296 × 60 = 2.0752 + 1.776 = 3.8512 g/dm^3

(b) What is the colour change during titration:
When MO was used: yellow to orange-red
When POP was used: pink to colourless

(c) Name the compounds reacted during the first and second titrations
First titration (MO): sodium hydroxide reacted with both hydrochloric acid and acetic acid
Second titration (POP): sodium hydroxide reacted with hydrochloric acid only

2. You are provided with the following:
A1: A solution of 0.2 M sodium thiosulphate
A2: A solution of 0.1 M hydrochloric acid
A3: Distilled water
Stop watch/clock
A sheet of white paper marked X

Table 2: Experimental Table (assume realistic times in seconds):

Experiment	Volume of A1 (cm^3)	Volume of A3 (cm^3)	Volume of A2 (cm^3)	Time (s)	1/time (s^{-1})
(a)	2	8	10	65	0.0154
(b)	4	6	10	43	0.0233
(c)	6	4	10	30	0.0333
(d)	8	2	10	23	0.0435
(e)	10	0	10	19	0.0526

Questions

(a) Write the ionic equation for the reaction.
$S_2O_3^{2-} + 2H^+$ -----> $S(s) + SO_2(g) + H_2O$

(b) Calculate the value of m.
Using experiments (a) and (b):
Rate $\propto [S_2O_3^{2-}]^m$
$Rate_1/Rate_2 = ([A1]_1/[A1]_2)^m$
0.0154 / 0.0233 = (2 / 4)^m
0.660 = (0.5)^m
log(0.660) = m × log(0.5)
m = log(0.660)/log(0.5) = -0.180/-0.301 = 0.60
Approximate m = 1

(c) Given n = 2, find K for (a) and (b)
Rate = K [A1]^m [A2]^n
K = rate / ([A1]^m × [A2]^n)

Convert volumes to concentrations:
Total volume = 2 + 8 + 10 = 20 cm^3 = 0.02 dm^3

[A1] = (0.2 × vol A1) / 20
[A2] = (0.1 × 10) / 20 = 0.05 M

For (a):
[A1] = 0.2 × 2 / 20 = 0.02 M
K = 0.0154 / ($0.02^1 \times 0.05^2$) = 0.0154 / (0.02 × 0.0025)
K = 0.0154 / 0.00005 = 308

For (b):
[A1] = 0.2 × 4 / 20 = 0.04 M
K = 0.0233 / (0.04 × 0.0025) = 0.0233 / 0.0001 = 233

Comment: K should be constant; variation shows experimental error or non-ideal behaviour.

(d) From the experiment conducted, is it possible to find value of n?
No. A2 volume is constant in all trials, hence n cannot be determined.

(e) What is the order of reaction in this experiment with respect to thiosulphate?
Since m ≈ 1, order = 1 with respect to thiosulphate.

3. Sample M is a simple salt containing one cation and one anion.

Questions

(i) Prepare a relevant Table showing the qualitative analysis results.

Test	Observation	Inference
Appearance	White crystalline solid	Possible chloride or nitrate
Heating	Colourless gas evolved	Volatile acid present
Solubility	Soluble in water	Ionic compound
NaOH solution	White ppt soluble in excess	Zn^{2+} present
$FeSO_4 + H_2SO_4$	Brown ring formed	NO_3^- ion confirmed
Lead ethanoate + heat	White ppt formed	SO_4^{2-} ion possibly present
Confirmatory test: $AgNO_3$ in HNO_3	White ppt	Cl^- confirmed

(ii) Write a balanced chemical equation for reaction in (b) (heating):
NH_4NO_3 -----> $N_2O + 2H_2O$ or
$Zn(NO_3)_2$ -----> $2NO_2 + O_2 + ZnO$ (depending on salt identity)