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: 2014**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following solutions:

L: 0.02 M potassium permanganate;

M: 39.2 g/dm³ hydrated ammonium iron (II) sulphate, $(NH_4)_2Fe(SO_4)_2.xH_2O$;

P: 1 M sulphuric acid.

(i) Write a half equation for the reduction of MnO_4^- ions to Mn^{2+} ions in acidic solution.

$MnO_4^- + 8H^+ + 5e^- \text{-----> } Mn^{2+} + 4H_2O$

(ii) Write a half equation for the oxidation of Fe^{2+} to Fe^{3+}

$Fe^{2+} \text{-----> } Fe^{3+} + e^-$

(iii) Write an ionic equation to show the oxidation of Fe^{2+} to Fe^{3+} by MnO_4^- ions in acidic solution.

$MnO_4^- + 5Fe^{2+} + 8H^+ \text{-----> } Mn^{2+} + 5Fe^{3+} + 4H_2O$

(iv) Deduce the value of x in hydrated ammonium iron (II) sulphate.

Relative molecular mass of anhydrous salt =

$(2 \times 18) + (2 \times 56) + (2 \times 96) = 284$ g/mol

Let x be the number of water molecules.

Total molar mass = 284 + 18x

Given concentration = 39.2 g/dm³

Number of moles = 39.2 / (284 + 18x) = 0.1 mol

Therefore:

(284 + 18x) = 392

18x = 392 - 284 = 108

x = 108 / 18 = 6

Value of x = 6

(v) Suggest two advantages and disadvantages of using $KMnO_4$ in volumetric analysis.

Advantages:

- It acts as its own indicator.

- It is a strong oxidizing agent, giving sharp endpoints.

Disadvantages:

- It is unstable in solution over time.

- It reacts with organic matter easily, affecting accuracy.

2. You are provided with the following:

U: 0.05 M hydrogen peroxide

V: 0.03 M sodium thiosulphate

W: 0.25 M sulphuric acid

X: 0.3 M potassium iodide

Y: Starch solution

Distilled water

Stop watch

Theory:

Hydrogen peroxide oxidizes iodide ions (I^-) to iodine (I_2). The iodine produced reacts with thiosulphate to form iodide ions again. The appearance of the blue colour (from starch–iodine complex) signals that all thiosulphate has reacted and iodine is now free in solution.

Overall relevant reactions:

(1) $H_2O_2 + 2H^+ + 2I^- \text{-----> } I_2 + 2H_2O$

(2) $I_2 + 2S_2O_3^{2-} \text{-----> } 2I^- + S_4O_6^{2-}$

The time taken for the blue colour to appear corresponds to the rate of iodine formation.

Questions

(a) Record all your observation results in a tabular form.

Mixture	X (cm^3)	Water (cm^3)	Time, t (sec)	1/t (sec^{-1})
A	5	20	75	0.0133
B	10	15	60	0.0167
C	15	10	42	0.0238
D	20	5	30	0.0333
E	25	0	20	0.0500

(b) Plot a graph of log(1/t) against log(volume of X).

First convert volumes of X and 1/t into logarithms:

Mixture	Volume of X (cm^3)	1/t (sec^{-1})	log(Volume of X)	log(1/t)
A	5	0.0133	0.6990	-1.876
B	10	0.0167	1.0000	-1.778
C	15	0.0238	1.1761	-1.623
D	20	0.0333	1.3010	-1.478
E	25	0.0500	1.3979	-1.301

(c) Calculate the gradient of the graph.

Use two points from the graph, for example:

Point 1: (1.0000, -1.778)

Point 2: (1.3979, -1.301)

Gradient (slope) = $(y_2 - y_1) / (x_2 - x_1)$

= (-1.301 - (-1.778)) / (1.3979 - 1.0000)

= (0.477) / (0.3979)

= 1.199 (approximately)

(d) Determine the order of reaction with respect to X.

The order of reaction is equal to the gradient from the graph.

So, order with respect to X = 1.2 ≈ 1

(e) Plan a simple procedure experiment that can be used to determine the order of reaction with respect to U.

Procedure:

1. Keep the volumes of V (thiosulphate), W (sulphuric acid), X (iodide), Y (starch), and water constant.

2. Prepare different concentrations of U (hydrogen peroxide) by diluting it with distilled water.

3. Measure 10 cm^3 of each diluted U solution and proceed with the same mixing and timing procedure used previously.

4. Record the time taken for blue colour to appear in each case.

5. Calculate 1/t for each reaction.

6. Plot log(1/t) against log[U] and determine the gradient of the graph.

7. The slope gives the order of reaction with respect to U.

3. You are provided with sample X containing one cation and one anion. Carry out the experiments described in Table 2. Record carefully your observations, make appropriate inferences and finally identify the anion and cation present in sample X.

Table 2: Table of results

(a) Appearance of sample X

Observation: White crystalline solid

Inference: Presence of a salt

(b) Heat a little sample X in a dry test tube

Observation: White fumes with pungent smell evolved

Inference: Presence of ammonium ion (NH_4^+)

(c) Prepare a sample solution X and divide the resulting solution into three portions

(i) To the first portion add NaOH

Observation: Ammonia gas evolved on warming

Inference: Confirm presence of NH_4^+

(ii) To the second portion add NH_4OH solution

Observation: No visible reaction

Inference: Absence of transition metal cations

(iii) To the third portion add $FeCl_3$ solution followed by dilute HCl then boil

Observation: A yellow solution forms, turning brown on boiling

Inference: Presence of oxalate ion ($C_2O_4^{2-}$)

(d) Perform flame test for sample X

Observation: No characteristic color observed

Inference: Confirms absence of metal ions giving colored flame

(e) Perform one confirmatory test for:

(i) Cation

Observation: NaOH added and warm → pungent smell of ammonia

Inference: NH_4^+ ion confirmed

(ii) Anion

Observation: $FeCl_3$ + HCl gives brown ring

Inference: Confirms oxalate ion

Conclusion:

(i) The cation in sample X is NH_4^+

(ii) The anion in sample X is $C_2O_4^{2-}$

(iii) The molecular formula for sample X is $(NH_4)_2C_2O_4$

(iv) Balanced chemical equation for the reaction in (b):

$(NH_4)_2C_2O_4(s)$ ----heat----> $2NH_3(g) + CO(g) + CO_2(g) + H_2O(g)$