THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3C **CHEMISTRY 3C**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2016**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:

S: A solution made by taking 10.00 cm^3 of 0.50 M $K_2Cr_2O_7$ and diluting it to exactly 0.25 dm^3 with distilled water

R: 5% KI solution

B: 1 M H_2SO_4 solution

T: Starch solution

Q: A solution of sodium thiosulphate

(a) Write down the half reaction equations to show the oxidation and reduction processes for reactions equation 1 and 2.

Oxidation (equation 1):

$2I^- \text{-----> } I_2 + 2e^-$

Reduction (equation 1):

$Cr_2O_7^{2-} + 14H^+ + 6e^- \text{-----> } 2Cr^{3+} + 7H_2O$

Oxidation (equation 2):

$S_2O_3^{2-} \text{-----> } S_4O_6^{2-} + 2e^-$

Reduction (equation 2):

$I_2 + 2e^- \text{-----> } 2I^-$

(b) For each reaction, identify the oxidant and the reductant. Give a reason for your answer.

Reaction 1:

Oxidant: $Cr_2O_7^{2-}$ (accepts electrons)

Reductant: I^- (loses electrons)

Reaction 2:

Oxidant: I_2 (accepts electrons)

Reductant: $S_2O_3^{2-}$ (loses electrons)

(c) Show mole relationship between $Cr_2O_7^{2-}$ and $S_2O_3^{2-}$ ions.

From the two equations:

1 mol $Cr_2O_7^{2-}$ produces 3 mol I_2

1 mol I_2 reacts with 2 mol $S_2O_3^{2-}$

Therefore,

1 mol $Cr_2O_7^{2-}$ -----> 3 mol I_2 -----> 6 mol $S_2O_3^{2-}$

Mole ratio: $Cr_2O_7^{2-}$: $S_2O_3^{2-}$ = 1 : 6

(d) Calculate the concentration of S in mol/dm³ and g/dm³.

Original solution: 10.00 cm³ of 0.50 M $K_2Cr_2O_7$ diluted to 250.0 cm³

Using $c_1v_1 = c_2v_2$:

$0.50 \times 10.00 = c_2 \times 250.0$

$c_2 = 0.50 \times 10.00 / 250.0 = 0.0200$ mol/dm³

To find g/dm³:

Molar mass of $K_2Cr_2O_7$ = 294.18 g/mol

g/dm³ = $0.0200 \times 294.18 = 5.8836$ g/dm³

(e) Calculate the concentration of Q in mol/dm³ and g/dm³.

Let's suppose the average volume used was 25.00 cm^3 (0.0250 dm^3) of Q to react with 25.00 cm^3 (0.0250 dm^3) of S.

From (c), mole ratio is 1 : 6

Moles of S used = 0.0200 mol/dm^3 × 0.0250 dm^3 = 5.00×10^{-4} mol

Moles of Q = 6 × 5.00×10^{-4} = 3.00×10^{-3} mol

Concentration of Q = moles / volume = 3.00×10^{-3} mol / 0.0250 dm^3 = 0.120 mol/dm^3

To find g/dm^3 (molar mass $Na_2S_2O_3$ = 158.11 g/mol):

0.120 × 158.11 = 18.9732 g/dm^3

(f) The pale green colouration at the end of the titration indicates the presence of Cr^{3+} in the solution.

2. You are provided with the following:

K_1: A solution of 0.05 M potassium iodate;

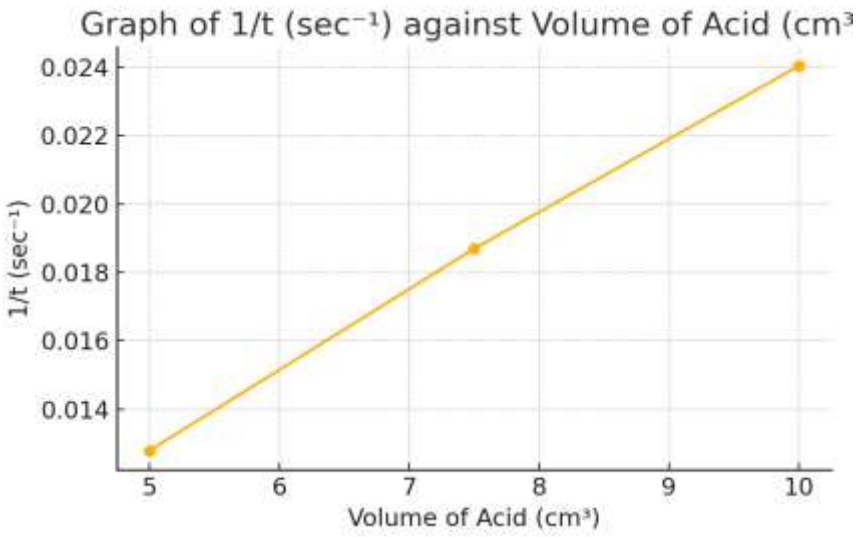
K_2: A solution of 0.1 M of sodium sulphite;

K_3: A solution of 0.1 M sulphuric acid;

• Starch solution;

• Stop watch/clock.

(a) Plot a graph of reciprocal of time against volume of acid.



(b) Determine the slope of the graph.

After plotting 1/t against V (acid), the slope is obtained from the straight line:

Slope = $\Delta(1/t) / \Delta V$

(c) If the volume of sulphuric acid is proportional to its concentration in the reaction mixture, suggest the order of reaction with respect to the acid.

From the table and procedure, the volume of K_3 (sulphuric acid) is varied while keeping other reactant volumes constant. The time taken for the appearance of the blue colour (indicating completion of the slow reaction 1 and start of rapid reaction 2) is measured. If plotting 1/t against volume of K_3 gives a straight-line graph, this implies that 1/t is directly proportional to the concentration (or volume) of sulphuric acid.

This suggests that the reaction rate is directly proportional to the concentration of sulphuric acid.

Therefore, the order of reaction with respect to sulphuric acid is 1.

(d) What is the rate constant for the reaction?

Let the rate law be:

rate = $k[H^+]^n$

From (c), n = 1. So:

rate = $k[H^+]$

We use the relation:

rate ≈ $1/t = k[H^+]$

Assuming volume of H_2SO_4 = V cm^3, and concentration = 0.1 M,

Moles of H^+ per cm^3 = 0.1 mol/dm^3 = 0.1 × 1/1000 mol/cm^3 = 0.0001 mol/cm^3

So for V cm^3:

$[H^+]$ = 0.0001 × V mol/cm^3

Let's pick one row from the experiment for calculation:

Suppose when V = 5 cm^3, time t = 100 seconds

Then,

$1/t = 1/100 = 0.01\ s^{-1}$

$[H^+]$ = 0.0001 × 5 = 0.0005 mol/cm^3

Then,

$k = (1/t) / [H^+]$

$k = 0.01 / 0.0005 = 20\ s^{-1} \cdot cm^3/mol$

Thus, the rate constant k is 20 $s^{-1} \cdot cm^3$/mol for that trial.

Repeat the calculation using other volumes of acid and average the values of k for improved accuracy.