TERM 2 - 2023

CHEMISTRY – PAPER 3 (233/3)

FORM FOUR (4)

MARKING SCHEME

1. You are provided with:

- Solution C1, an aqueous solution of potassium iodate (V) of concentration 4.06 g/dm^3.
- Solution C2, an aqueous solution of sodium thiosulphate of unknown concentration.
- Solution C3, an acidified solution of potassium iodide.
- Solution C4, starch indicator solution.

Section 1

You are required to:

a) React solution C3 with C1 to liberate a certain quantity of iodine.

b) Titrate the iodine liberated in the reaction between C3 and C1 against solution C2 to determine the molar concentration of C2.

Procedure

(a) Fill the burette with solution C2.

(b) Pipette 25.0 cm^3 of solution C1 into a 250 ml conical flask.

(c) Using a measuring cylinder, transfer 15.0cm^3 of solution C3 into a conical the conical flask with solution C1.

(d) Titrate the solution in the conical flask against solution C2 from the burette until the brown colour just changes to pale yellow.

(e) Using a 10 ml measuring cylinder, add 5cm^3 of solution C4 into the mixture in the conical flask and then continue titrating until the blue colour just disappears.

(f) Record your titration results in table 1 below.

(g) Repeat the procedure (b) to (f) above two more times and complete table 1 below.

(4 marks)

Table 1	I	II	II
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of solution C2 (cm^3) added			

CT = 1
DP = 1
AC = 1
PA = 1
FA = 1
5

(a) Determine the average volume of C2 used. (1 mark)

23.71 cm^3

(d) Potassium iodate (V) solution reacts with acidified potassium iodide solution to liberate iodine as per the following ionic equation.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

(colourless) (brown)

(ii) Sodium thiosulphate reduces iodine to iodide ions as per the ionic equation below:

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(Brown) (colourless)

(b) Calculate the:

(i) concentration of C1 in moles per litre. (K = 39, O = 16, I = 127) (1 mark)

MM = 39 + 127 + (16 × 3) = 214

molarity = $\frac{4.06}{214}$ = 0.01897 M

(ii) number of moles of potassium iodate (V) contained in 25cm^3 of solution C1. (1 mark)

0.01897 moles → 1000 cm^3

? → 25 cm^3

$\frac{25 \times 0.01897}{1000}$ = 0.00047425 moles

(iii) number of moles of sodium thiosulphate in the average volume of solution C2 used. (1 mark)

MR IO_3^- : $S_2O_3^{2-}$

1 : 5

0.00047425 : x

x = 0.00047425 × 5

= 0.002371 moles.

(iv) molarity of solution C2. (1mark)

0.002371 moles → 23.71 cm^3

? → 1000 cm^3

$\frac{1000 \times 0.002371}{23.71}$ = 0.1 M

Section 2

You are provided with:

- solution C4, starch indicator solution.
- Solution C5, an acidified mixture of potassium iodide and sodium thiosulphate.

- Solution C6, hydrogen peroxide solution.
- Distilled water.

You are required to find out the effect of change in concentration of hydrogen peroxide solution on the rate of its reaction with acidified potassium iodide solution.

Procedure

I. Take six test tubes and label them 1 to 6.

II. Place solution C6 into a clean burette. Measure out the volumes of solution C6 as shown in table 2 below into the six test tubes.

III. Using a 10 ml measuring cylinder, add distilled water into EACH of the six test tubes as indicated in **table 2**.

IV. Using a clean measuring cylinder, measure 10 cm^3 of solution C5 into a 100 ml beaker followed by 5.0 cm^3 of solution C4 and swirl the mixture.

V. Pour the contents to test tube 1 into the 100 ml beaker and immediately start the stop-watch.

VI. Swirl the contents of the beaker, place the beaker on a white tile and record the time taken (in seconds) for the blue colour to appear in **table 2**.

VII. Repeat procedures IV to VI above five more times using the contents of the test tubes 2 to 6, each time recording the time taken for the blue colour to appear in **table 2**.

VIII. Complete the table 2 by working out the reciprocal of time ($\frac{1}{t}$) for each experiment. This represents the reaction rate for each experiment.

Table 2 (6 marks)

Experiment	**1**	**2**	**3**	**4**	**5**	**6**
Tes tube number	1	2	3	4	5	6
Volume of solution C6 (cm^3)	10.0	8.0	6.0	4.0	3.0	2.0
Volume of distilled water (cm^3)	0.0	2.0	4.0	6.0	7.0	8.0
Volume of solution C4 used (cm^3)	5.0	5.0	5.0	5.0	5.0	5.0
Volume of solution C5 used (cm^3)	10.0	10.0	10.0	10.0	10.0	10.0
Time taken for the blue colour to appear (seconds)						
Rate $\frac{1}{t}$ (s^{-1})						

Marking of table 2

Complete table (CT) = 1 mark

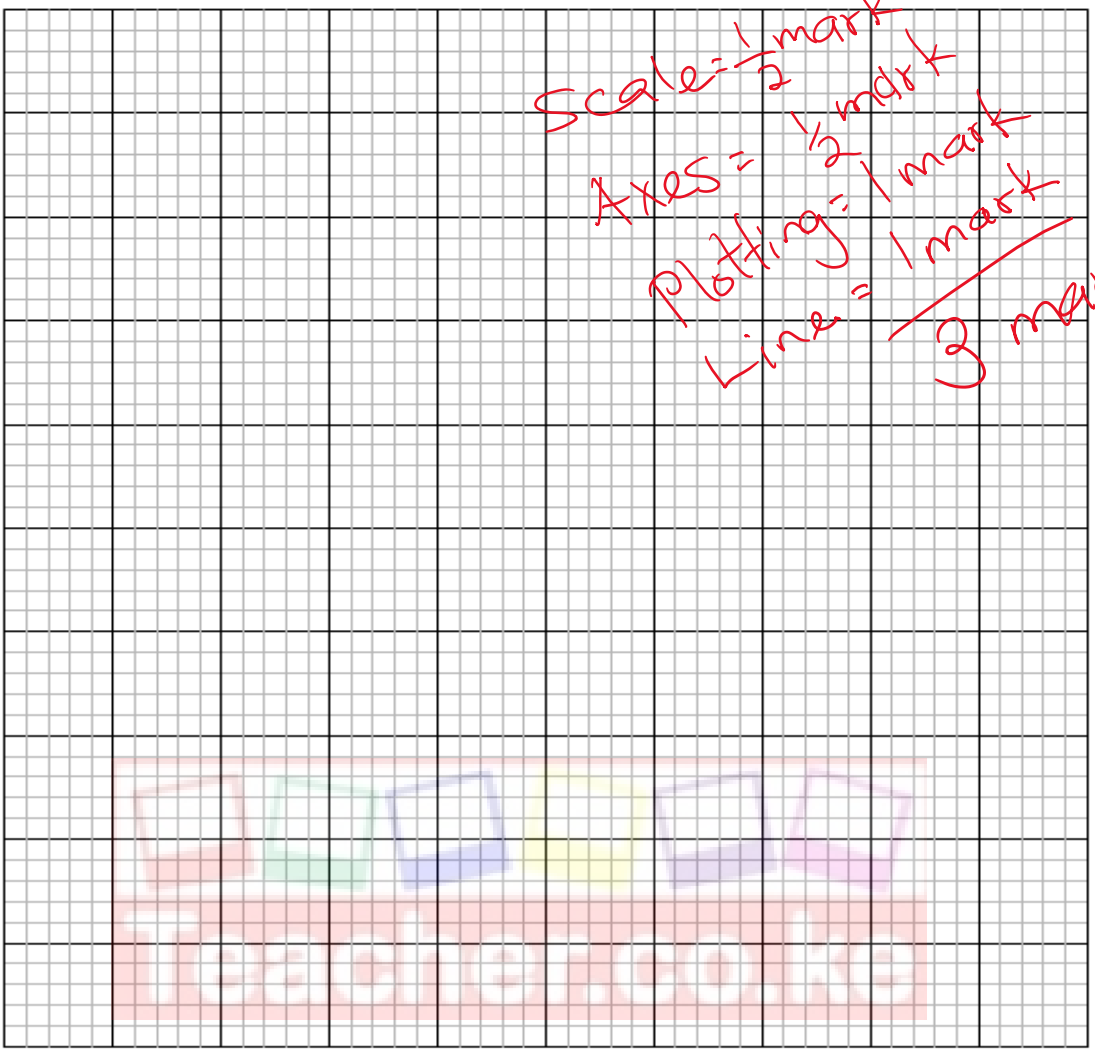
Decimal points (DP) = 1 mark

Trend (Tr) = 1 mark

Accuracy (AC) = 1 mark (Subject to School value (SV) only on the time recorded for experiment 1.)

Calculation of reciprocal = 2 marks

(a) On the grid provided, plot a graph of rate of reaction (vertical axis) against the volume of solution C6 used. (3 marks)



Marking notes:

- **The line should be a straight line of best-fit passing through the origin.**
- **Scale: plots must cover a least ½ of the grid provided.**
- **Axes must be both correctly labelled.**
- **Plots: All plots are correct = 1 mark, 4 -5 correct plots = ½ mark, 3 or less correct plots = 0 marks.**

(b) Using the graph, determine the time taken for the blue colour to appear using a mixture of 5.0 cm^3 of solution C6 and 5.0 cm^3 of distilled water. (2 marks)

Correct reading from a correct graph = 1 mark (only award if the line of the graph is correct)

Conversion from rate to time = 1 mark

(c) What is the effect of adding more distilled water to the hydrogen peroxide solution on the rate of this reaction with acidified potassium iodide solution? Explain. (2 marks)

Adding more distilled water reduces the concentration of hydrogen peroxide hence the rate of reaction also decreases. This is because there are fewer reacting particles per unit volume hence the number of effective collisions decreases. As a result, the rate of reaction decreases.

2. You are provided with solid D1. Carry out the following tests and write your observations and inferences in the spaces provided.

(a) Place all solid D1 in a boiling tube. Add about $10cm^3$ of distilled water and shake. Divide the mixture into four portions.

Observations	Inferences
Solid dissolves to form a colourless solution. (1 mark)	**Solid is soluble** **Cu^{2+} , Fe^{2+} , Fe^{3+} absent** (1 mark)

(b) To the first portion, add sodium hydroxide dropwise until in excess.

Observations	Inferences
White precipitate, soluble in excess. (1 mark)	**Zn^{2+} , Pb^{2+} , Al^{3+} present.** (1 mark)

(c) To the second portion, add aqueous ammonia dropwise until in excess.

Observations	Inferences
White precipitate, soluble in excess. (1 mark)	**Zn^{2+} present.** (1 mark)

(d) To the third portion, add 3 drops of barium nitrate followed by 2 cm^3 of 2M nitric (V) acid.

Observations	Inferences

White precipitate that does not dissolve on the addition of nitric (V) acid. (1 mark)	SO_4^{2-} present (1 mark)

(e) To the fourth portion, add 1 cm^3 sodium hydroxide followed by aluminium foil and warm the mixture. Test any gases produced using red litmus paper.

Observations	Inferences
Effervescence. A colourless gas which changes moist red litmus paper blue is formed. (1 mark)	NO_3^- present (1 mark)

3. You are provided with solid M1.
Carry out the tests below and write your observations and inferences in the spaces provided.

a. Place about half of solid M1 in a metallic spatula and burn it in a non-luminous flame.

Observations	Inferences
Solid burns with a yellow sooty flame (1 mark)	$-C=C-$, $-C\equiv C-$ present (1 mark)

b. *Place the remaining solid M1 in a boiling tube. Add* about 6 cm^3 of distilled water and shake the boiling tube. Divide the solution into three portions. To the first portion, add 2 drops of bromine water.

Observations	Inferences
Yellow bromine water changes to colourless. (1 mark)	$-C=C-$, $-C\equiv C-$ present (1 mark)

ii. To the second portion, add all the sodium carbonate. Test for any gases using a burning splint.

Observations	Inferences
Effervescence.	$-C(=O)-OH$

A colourless gas that extinguishes a burning splint is evolved. (1 mark)	R- present (1 mark)

iii. To the third portion, add 3 drops of acidified potassium dichromate (VI)

Observations	**Inferences**
Orange acidified potassium dichromate (VI) remains orange. (1 mark)	R-OH absent (1 mark)

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