This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School

for Boys and Girls Loueizeh - Baabda

Stage Exam 02

19DEC2022

Do NOT write in this box. Your MARK will be placed here.

Subject :	Chemistry
Class :	12M and 12E
Teacher :	Mrs. Saydeh Nasrallah
Duration :	1 hour
Graph paper is needed	

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

First Exercise (6.5 points)
A Scale Product for Coffee-Pot

The main constituent of a scale product is sulfamic acid. It is sold commercially as white small crystals.
The aim of this exercise is to determine the percentage of sulfamic acid in the scale product by pH-metry.

Given:
- Sulfamic acid of formula NH_2SO_3H will be represented as HA in this exercise.
- Molar mass of sulfamic acid in $g.mol^{-1}$: M = 97.1

Experimental Procedure:

first step: 2.05 g of this scale product are dissolved in distilled water to obtain a solution (S) of volume V = 500 mL.
second step: A volume V_a = 10 mL of solution (S) is put into a beaker. A volume V′ of distilled water is then added to immerse the electrode of the pH-meter.
third step: Titration is carried out by using sodium hydroxide solution of concentration $C_b = 4x10^{-2} mol.L^{-1}$.

I- Preliminary Study

1.1- Sulfamic acid is a strong acid. Write the equation of the reaction of this acid with water.
1.2- Indicate the appropriate material used to:
- weigh the mass of 2.05 g
- prepare the volume V
- withdraw the volume V_a
- add the sodium hydroxide solution.

1.3- Write the equation of the titration reaction.
1.4- Based on the chemical species which are present in the beaker, justify the value of pH = 7 at the equivalence point.

II- Make Use of the Titration Results

Part of the titration results is given in the following table:

V_b(mL)	0	10.4	15
pH	2.4	7.0	11.0

2.1- Draw the shape of the curve pH = f(V_b) for $0 \leq V_b \leq 15$ mL.
Take the following scales: abscissa: 1cm for 1mL, ordinate: 1 cm for 1 unit of pH.
2.2- Determine the concentration C_a of sulfamic acid in solution (S).
2.3- Deduce the mass percentage of sulfamic acid in this scale product.

Second Exercise (3.5 points)
Kinetic of the Decomposition of Hydrogen Peroxide H_2O_2

In this exercise, the aim is to study the kinetic of the decomposition reaction of H_2O_2 according the following equation:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g).$$

Given:

- The decomposition of H_2O_2 is spontaneous and complete.
- The gas O_2 is very slightly soluble in water at the temperature of this study.
- Iron (III) chloride $FeCl_3$, used as a catalyst in this reaction, is highly soluble in water.

A solution (S) of concentration $C = 0.060\, mol.L^{-1}$ is used in this experiment.

Kinetic of the Decomposition Reaction of H_2O_2

A little amount of powdered iron (III) chloride is added, without any change in volume, into a round bottom flask containing 50 mL of solution (S) of concentration $C = 0.060\, mol.L^{-1}$.
A convenient setup is connected to the flask in order to measure the pressure P of the gaseous phase in the flask.
The values of the pressure P, versus time t, are given in the following table:

P $(10^2\, Pa)$	1015	1038	1055	1070	1081	1093	1100	1104	1106
t (min)	0	5	10	15	20	30	40	50	60

In this study, O_2 produced by the decomposition of H_2O_2 occupies a volume V = 300 mL in the flask which is maintained at a constant temperature T = 300 K.

1- Consider:
n_t: quantity in moles of O_2 produced at each instant t;
P_0: initial pressure in the flask at t = 0 before any decomposition of H_2O_2.

Show that $n_t = 1.2\,x\,10^{-7}(P - P_0)$;
Take $R = 8.3\, m^3.Pa.mol^{-1}.K^{-1}$.

2- Identify the species present in the solution when the pressure P is equal to $1140\,x\,10^2\, Pa$.

3- Choose the correct answer. Justify.

3.1- The rate of a reaction at a given instant t denoted by r_{rxn} and the rate of disappearance of H_2O_2 at the same instant t denoted by $r_{(H_2O_2)t}$ are related by the following relation:

a) $r_{rxn} = \dfrac{r_{(H_2O_2)t}}{2}$ b) $r_{rxn} = 2\, r_{(H_2O_2)t}$ c) $r_{rxn} = r_{(H_2O_2)t}$

3.2- When the above experiment is carried out at a temperature T'> T(as the only modification), the relation between half-life time $t'_{½}$ at temperature T' and half-life time $t_{½}$ at temperature T, is:

a) $t'_{½} = t_{½}$ b) $t'_{½} < t_{½}$ c) $t'_{½} > t_{½}$

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First exercise

I- Preliminary Study

1.1- $HA + H_2O \longrightarrow H_3O^+ + A^-$ ✓ (1/2)

1.2- . A digital scale to weigh 2.05 g ✓ (1/4)

. A 500 ml volumetric flask to prepare V. ✓ (1/4)

. A 10 ml volumetric pipette fitted with a pipette filler to withdraw V_a. ✓ (1/4)

. Use 25 ml burette to add NaOH. ✓ (1/4)

1.3- $H_3O^+ + OH^- \longrightarrow 2H_2O$ ✓ (1/2)

1.4- At equivalence point, the species present are H_2O, A^- & Na^+. ✓ (1/2)
A^- and Na^+ are spectator ions. ✓ (1/4)
Hence, the only specie affecting the pH is water, whose pH = 7. ✓ (1/4)

II- Make use of the titration results.

2.1- On graph paper

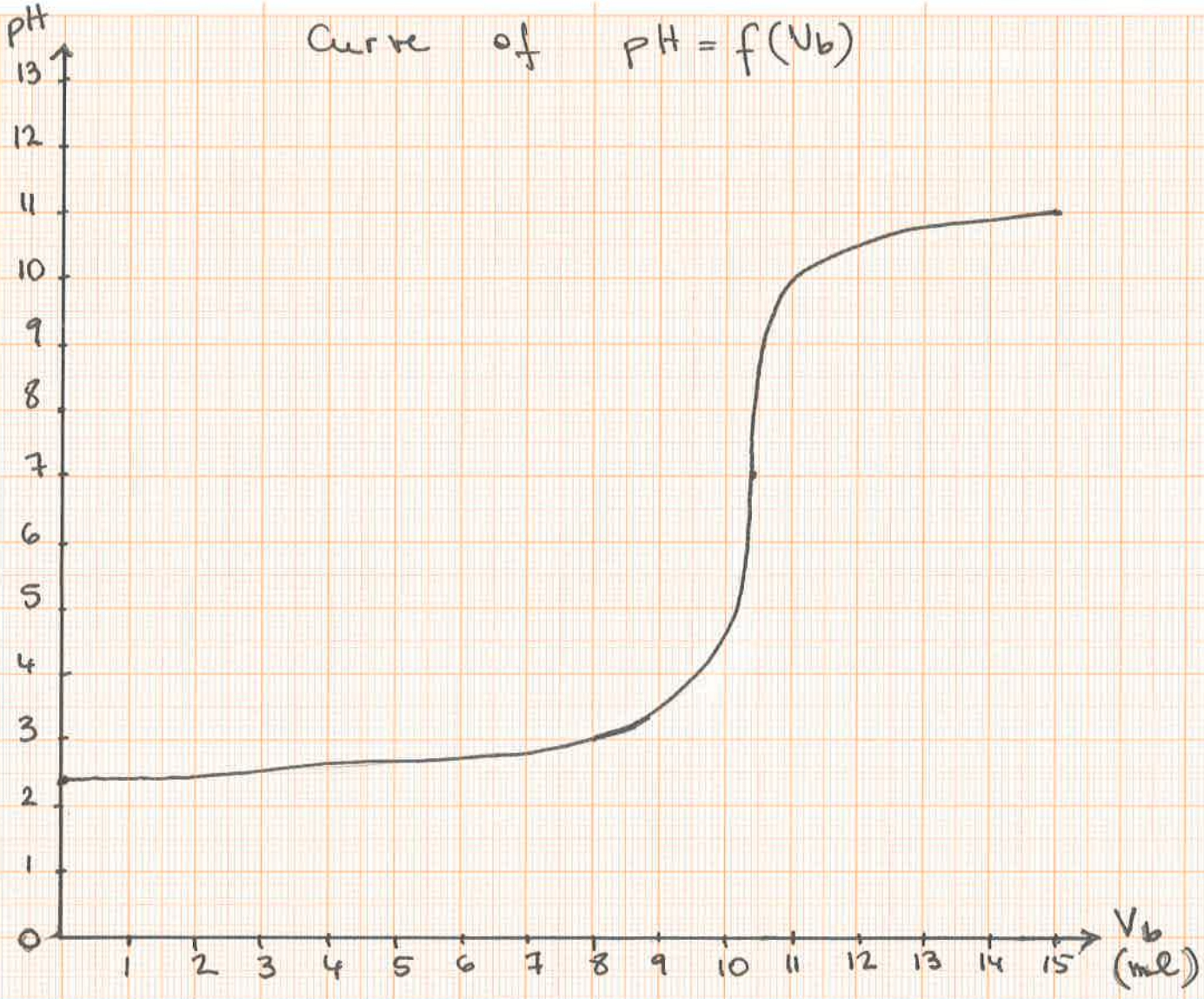
2.2- At equivalence point: $n_{H_3O^+} = n_{OH^-}$ ✓ (1/4)

$\Rightarrow C_a.V_a = C_b.V_b$ ✓ (1/4)

$\Rightarrow C_a = \frac{4\times10^{-2} \times 10.4}{10} = 0.0416$ mol.L^{-1} ✓ (1/2)

or 4.16×10^{-2} mol.L^{-1}

Curve of $pH = f(V_b)$



- axes properly labelled : (1/4)
- points plotted properly (1/4)
- correct shape of curve (1/2)

2.3 - $n_{(HA)} = 0.0416 \times 0.5 = 0.0208$ mol ✓ (1/2)

$\Rightarrow m_{(HA)} = 0.0208 \times 97.1 = 2.01968$ g ✓ (1/2)

$\Rightarrow$ % mass of HA $= \frac{2.01968}{2.05} \times 100$

% mass of HA $= 98.5$ % ✓ (1/2)

Second Exercise

1 -

	$2H_2O_2$	$\longrightarrow$	$2H_2O$	+	O_2
t=0	n_0		-		-
t	$n_0 - 2n_t$		$2n_t$		n_t.

✓ (1/4)

at time t : n_t : moles of O_2

P : total pressure

P_t : pressure of O_2

$P_t . V = n_t . R . T$

$\Rightarrow n_t = \frac{P_t . V}{R . T} = \frac{(P - P_0) \times 300 \times 10^{-6}}{8.3 \times 300}$ ✓ (1/4) ✓ (1/4)

$\Rightarrow n_t = 1.2 \times 10^{-7} (P - P_0)$ (verified) ✓ (1/2)

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2- for $P = 1140 \times 10^2$, $n_t = 1.2 \times 10^{-7} (1140 \times 10^2 - 1015 \times 10^2)$

$\Rightarrow n_t = 1.2 \times 10^{-7} \times 1.25 \times 10^4$

$\Rightarrow n_t = 1.5 \times 10^{-3}$ mol ✓ (1/2)

at time t: $n_{H_2O_2(t)} = n_0 - 2n_t$

$\Rightarrow n_{H_2O_2(t)} = 0.06 \times 50 \times 10^{-3} - 2 \times 1.5 \times 10^{-3}$

$= 3 \times 10^{-3} - 3 \times 10^{-3} = 0$ ✓ (1/4)

Therefore, at instant t, H_2O_2 would have decomposed completely. Hence, the species present in the beaker would be only H_2O, (1/4)
Fe^{3+}, and Cl^- (1/4)

3- 3.1- By stoichiometry ✓

$r_{rxn} = \frac{r_{H_2O_2}}{S.C} = \frac{r_{(H_2O_2)t}}{2}$ ✓ (1/4) Answer: a (1/4)

3.2- at $T' > T$, the particles have higher kinetic energy, which leads to a greater rate of successful collisions. Hence, more reactants are used within shorter period of time (1/4)

$\Rightarrow t'_{1/2} < t_{1/2}$ Answer: b. (1/4)