وزارة التربية والتعليم العالي
المديريّة العامّة للتربية
دائرة الامتحانات الرسميّة

امتحانات الشهادة الثانوية العامة
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دورة العام ٢٠١٩ العاديّة
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مكيفة

مسابقة في مادة الكيمياء
المدة: ساعتان

This Exam Includes Three Exercises. It Is Inscribed On Ten Pages Numbered From 1 to 10.
The Use of a Non-programmable Calculator Is Allowed.

مسابقة في مادة الكيمياء

المدة: ساعتان

(انكليزي)

الاسم:...........................

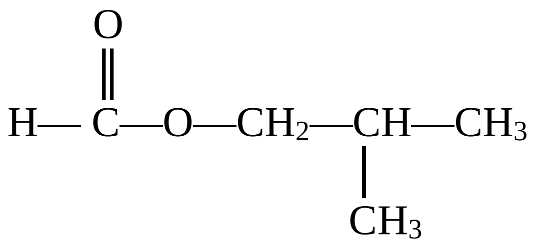
الرقم: ....

Answer the Following Three Exercises:

Exercise 1 (7 points)

Synthesis of an Organic Compound

The organic compound (E) of raspberry odor is used in food industry. The condensed structural formula of this compound is represented in **document-1.**



Document-1

1. Study of the Structure of The Compound (E)

1.1. **Name** the functional group of this compound.

1.2. **Give** the systematic name of (E).

2. Preparation of the compound (E)

The compound (E) can be obtained from **the reaction** of a carboxylic acid (A) and an alcohol (B).

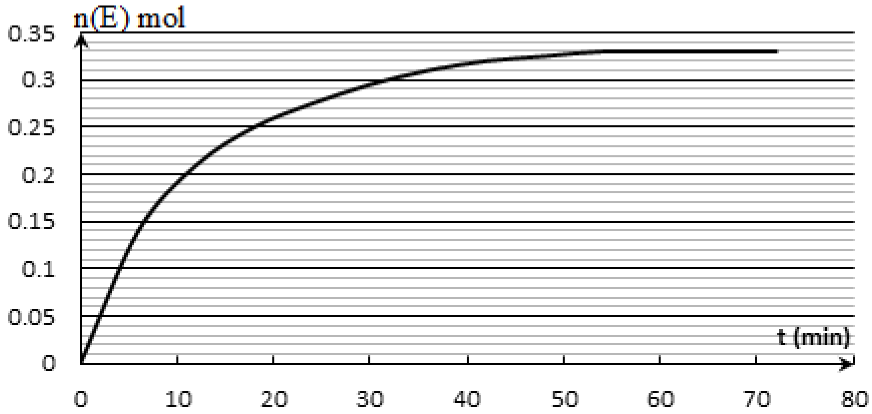
2.1. **Identify** the carboxylic acid (A) and the alcohol (B).

2.2. **Indicate** the class of the alcohol (B).

2.3. **Write**, using condensed structural formulas, the equation of the preparation reaction of the compound (E) starting from the compounds (A) and (B).

2.4. At the instant of time t = 0, a quantity of 0.5 mol of (A) is mixed with 0.5 mol (B), then few drops of concentrated sulfuric acid are added and the mixture is heated to reflux at constant temperature **T**.

The curve of the **document-2** represents the evolution of the number of moles of the compound (E) formed as a function of time.



Document-2

2.4.1. Determine the theoretical number of moles of the organic compound (E) formed **at the end of the reaction.**

2.4.2. Referring to the document-2, **justify** each of the following propositions:

Proposition 1: The reaction of preparation of the compound (E) is **slow**.

Proposition 2: The reaction of preparation of the compound (E) is **limited**.

2.4.3. Calculate the yield of this reaction at equilibrium.

$$r = \frac{n\ (E)\ \text{experimental}}{n\ (E)\ \text{theoretical}} \times 100$$

In order to increase the yield of this reaction, the two experiments of **doc. 3** are suggested:

	Carboxylic acid (A)	**Alcohol (B)**	**Sulfuric acid**	**Temperature**
Experiment 1	0.5 mol	0.5 mol	Few drops	$\mathbf{T_1 > T}$
Experiment 2	0.5 mol	**2.5 mol**	Few drops	T

Document-3

2.5. **Specify** whether the yield increases in each experiment of **document-3**.

2.6. The yield can be increased by using a chlorinated acid derivative (D) instead of the carboxylic acid (A).

2.6.1. Write the condensed structural formula of the compound (D).

2.6.2. Name the compound (D).

Exercise 2 (7 points) **Titration of Vinegar**

Vinegar is an **aqueous ethanoic acid solution**.

The aim of this exercise is <u>to determine the degree of acidity of a white commercial vinegar.</u>

- The condensed structural formula **of ethanoic acid is CH_3COOH.**

Document-1

Given:

- Density of vinegar: d = 1.020 $g.mL^{-1}$.
- The molar mass of ethanoic acid is: M = 60 $g.mol^{-1}$.
- The study is carried out at 25°C.

1. **Preparation of a Diluted Solution (S) of Vinegar**

A commercial white vinegar solution (S_0) is diluted 100 times. A solution (S) is obtained.

a) **Choose** from doc. 2 the most convenient set in order to prepare the solution (S).

b) **Justify** your answer.

Set 1	Set 2
• Volumetric flask of 250 mL • Graduated pipet of 5 mL • Beaker of 50 mL	• Volumetric flask of 250 mL • Graduated cylinder of 5 mL • Beaker of 50 mL

Document-2

2. **pH-metric Titration of The Solution (S)**

A volume **V_a = 20.0 mL** of the solution (S) is introduced into a beaker then distilled water is added in order to immerse properly the pH-meter electrode. A pH-metric titration is realized by adding progressively into the beaker **a sodium hydroxide solution ($Na^+ + HO^-$) of molar concentration**

$C_b = 2.0 \times 10^{-2}$ $mol.L^{-1}$.

The results are grouped in the table of **document-3**.

V_b (mL)	0	2	4	6	8	9	10	11	12	14
pH	3.5	4.3	4.7	5.0	5.5	5.8	8.2	10.8	11.0	11.2

Document-3

2.1. **Plot** the curve that represents the variation of the pH of the solution as a function of the volume of the base added: **pH = f (V_b).**

Take the following scales:

In abscissa: 1 cm ⟶ 1 mL ; in ordinates: 1 cm ⟶1 pH unit.

2.2. Referring to **the curve pH = f (V_b) :**

2.2.1. **Determine** the coordinates of the equivalence point.

2.2.2. **Give** two reasons that verify that ethanoic acid is a weak acid.

2.3. **Write** the equation of the titration reaction between the ethanoic acid **CH_3COOH** and sodium hydroxide **($Na^+ + HO^-$).**

2.4. **Show that** the molar concentration of ethanoic acid in solution **(S):**

$C = 1\times10^{-2}$ mol.L^{-1}

2.5.

The degree of acidity of vinegar corresponds to the mass (in g) of ethanoic acid in 100g of vinegar.

Document - 2

a) **Deduce** the molar concentration of the commercial solution S_0 of white vinegar.

b) **Deduce, referring to document-2,** the degree of acidity of the commercial white vinegar solution S_0.

2.6. Methyl orange is an acid - base indicator with a pH change range:

red - 3.1 - 4.4- yellow

Justify that methyl orange is not the appropriate indicator for this titration.

3. Reaction of Vinegar with Sodium Hydrogen Carbonate

Given:

- pKa (CO_2,H_2O / HCO_3^-) = 6.4 ; pKa (CH_3COOH/CH_3COO^-) = 4.8
- CO_2 is a gas slightly soluble in water.

A volume of white vinegar is introduced into a flask containing sodium hydrogen carbonate.

A limited reaction takes place according to the following equation:

$$\mathbf{CH_3COOH + HCO_3^- \rightleftarrows CH_3COO^- + CO_2\ H_2O}$$

3.1.Calculate the reaction constant Kr of this reaction.

3.2. Verify that this reaction is limited.

Exercise 3 (6 points) **Kinetic Study of a Slow Reaction**

Zinc reacts with hydrochloric acid solution according to a slow and complete reaction which is represented by the following equation:

$$Zn_{(s)} + 2\,H_3O^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + 2\,H_2O_{(l)} + H_{2\,(g)}$$

The aim of this exercise is to study the kinetic of this reaction.

Given:

- The study takes place at 25 ^{0}C.
- Zn^{2+} and $C\ell^-$ are spectator ions with no acid and base character.
- Hydrogen gas (H_2) is insoluble in water.

A mass m of powdered zinc is introduced into a flask containing a volume V_0 = 100 mL of hydrochloric acid solution ($H_3O^+ + C\ell^-$) of molar concentration C_o and pH_o as initial pH. **The reacting mixture is a stoichiometric mixture.**

1. Preliminary Study

Knowing that the pH of a solution is determined by the relation **pH = -log [H_3O^+]:**

Choose, with **justification** the answer**:**

1.1. the relation between pH_o and C_o :

$C_o = \frac{1}{pH_0}$ $\qquad\qquad$ $C_o = \frac{1}{10^{pH_0}}$

1.2. the variation of pH with time

pH increases $\qquad\qquad$ pH decreases

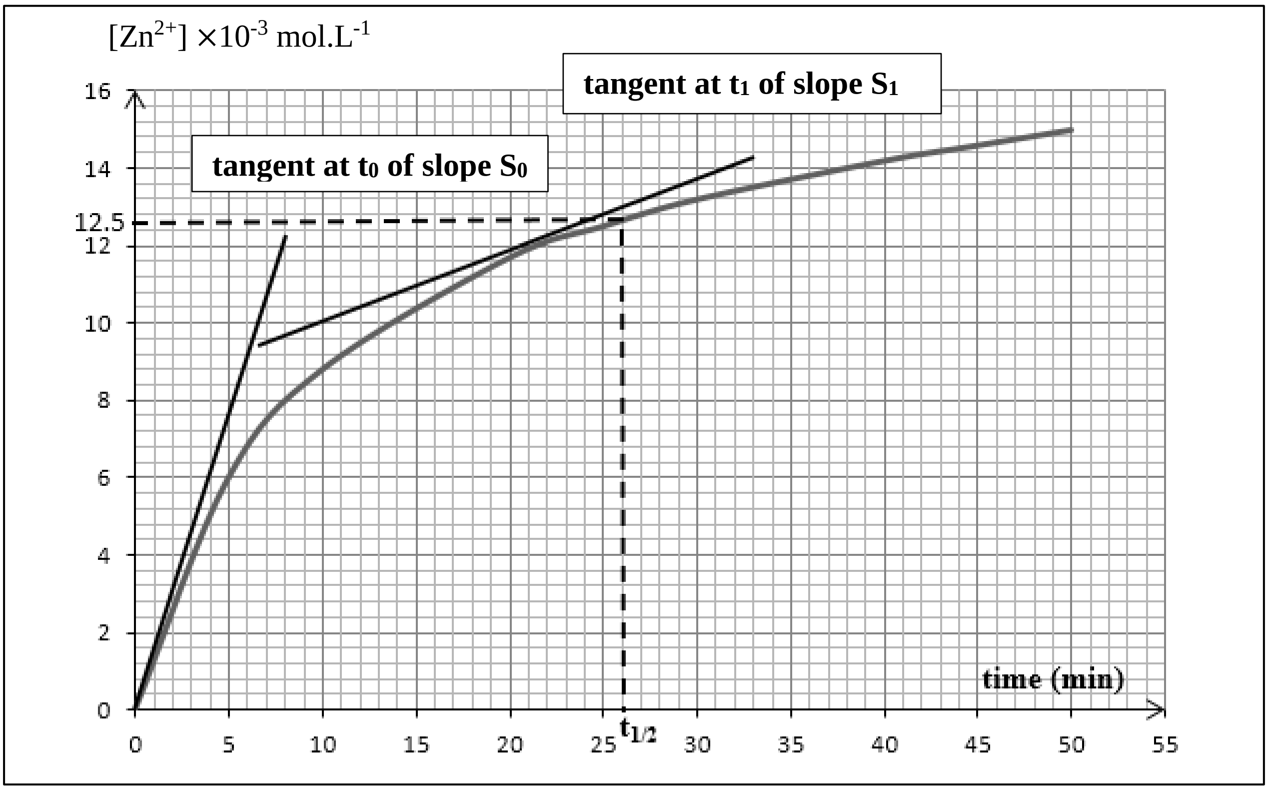
1.3. Knowing that the reaction is complete.

a) **Specify** the chemical species present in the reacting mixture at the end of the reaction

b) **Deduce** that the value of the pH at the end of the reaction is equal to 7.

2. Kinetic Study

The follow-up of the evolution of <u>the molar concentration</u> of the Zn^{2+} ions as a function of time, using an appropriate method, permits to plot the curve $[Zn^{2+}] = f(t)$ represented by the **document-1.**



Document-1

2.1. By referring to **document-1**:

2.1.1.Deduce the variation of the rate of formation of Zn^{2+} ions with time.

2.1.2.Show that the value of the concentration of Zn^{2+} ions at the end of the reaction is equal to 25×10^{-3} mol.L^{-1}

2.1.3. Show that the concentration $C_0 = 50 \times 10^{-3}$ mol.L^{-1}

2.2 Choose the relation between the initial rate of disappearance of H_3O^+ ions $r_o(H_3O^+)$ and the slope S_o of the tangent.

By referring to the equation of the reaction:

$$Zn_{(s)} + 2\,H_3O^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + 2\,H_2O_{(l)} + H_{2\,(g)}$$

a. $r_o(H_3O^+) = 2\,S_o$

b. $r_o(H_3O^+) = S_o$

c. $r_o(H_3O^+) = -2S_o$

2.3 The concentration of the Zn^{2+} ions, noted $[Zn^{2+}]_{(t)}$ formed at each instant of time t of the evolution of the reacting system is related to the pH of the solution by the relation:

$$[Zn^{2+}]_t = \frac{1}{2}(C_o - 10^{-pH}).$$

2.3.1 Determine, by referring to the document -1, the molar concentration of the[Zn^{2+}] at t=5 min.

2.3.2 Deduce the pH of the solution at t = 5 min, knowing that C_o= 50 ×10 $^{-3}$ mol.L^{-1}

3 Study of The Effect of a Kinetic Factor

The previous experiment is carried out again but with only one modification: a volume V_o = 100 mL of a hydrochloric acid solution is used of molar concentration $C_1 > C_o$ is used

For each proposition **answer by true or false**. **Justify** you answer.

3.1. The molar concentration of Zn^{2+} ions at t = 5 min remains equal to 6×10^{-3} mol.L^{-1}.

3.2. The molar concentration of Zn^{2+} ions at the end of the reaction is equal to that found in the question (**2.1.2),** knowing that Zn remains the limiting reactant**.**