وزارة التربية والتعليم العالي
المديريّـة العامة للتربية
دائرة الامتحانات الرسمية

امتحانات الشهادة الثانوية العامة
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مكيفة / إحتياجات خاصة

مسابقة في مادة الكيمياء — الاسم:
المدة: ساعتان — الرقم:

This Exam Includes Three Exercises. It Is Inscribed on 8 Pages Numbered From 1 to 8 .
The Use Of Non- Programmable Calculator Is Allowed.
Answer The Following Three Exercises:

مسابقة في مادة الكيمياء

المدة: ساعتان

(باللغة الإنكليزية)

الاسم:............................

الرقم: ....

Exercise 1: (6 points) **Caustic Soda " NaOH"**

In the laboratory, caustic soda is found as pellets. Sodium hydroxide NaOH or caustic soda is a strong base that is highly soluble in water. A flask contains pellets of NaOH without any indication about their purity.

The aim of this exercise is to determine the degree of purity of sodium hydroxide in the pellets of caustic soda and to study the reaction between this base and a weak acid.

Given: Molar mass of NaOH: $M_{(NaOH)} = 40$ g.mol^{-1}.

1. Preparation of Sodium Hydroxide Solution (S)

A volume V=1 L of the solution (S) is prepared by dissolving a mass m = 1.20 g of sodium hydroxide pellets in distilled water.

- List the essential material needed to prepare the solution (S).

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

A volume V_b= 20.0 mL of the solution (S) of concentration C_b is poured into a beaker and distilled water is added to immerse properly the pH-meter electrode.

A pH-metric titration is carried out by adding gradually a hydrochloric acid solution (H_3O^+ + $C\ell^-$) of concentration C_a = 0.05 mol.L^{-1} into the beaker . The volume of the acid solution added to reach equivalence is V_{aE} = 11.2 mL.

2.1. Write the equation of the titration reaction.

2.2. Show that the concentration of the sodium hydroxide solution (S) is

$C_b = 0.028\ mol.L^{-1}$.

2.3. Knowing that the percentage by mass of NaOH is calculated as : Percentage by mass = $\frac{m_{NaOH}}{m_{pellets}}$ x 100

- **Find** m(NaOH) in 1 L of solution.
- **Calculate** the percentage.

2.4. Each of the following propositions is correct. **Justify :**

2.4.1. The addition of distilled water into the beaker before titration does not affect V_{aE}.

2.4.2. The bromothymol blue (Yellow 6 – 7.6 Blue) is one of the appropriate colored indicators to carry out this titration.

3. Reaction of Sodium Hydroxide with Benzoic Acid

Given: pK_a (C_6H_5COOH / $C_6H_5COO^-$) = 4.2 ; pK_a (H_2O / HO^-) = 14

A volume V_1 = 20 mL of the sodium hydroxide solution (S) of concentration $C_b = 0.028\ mol.L^{-1}$ is added to a beaker containing a volume V_2 = 30 mL of benzoic acid solution (C_6H_5COOH) of concentration $C_2 = 0.04 mol.L^{-1}$.

3.1. Complete the equation of the reaction taking place between benzoic acid and hydroxide ions HO^-:

$C_6H_5COOH + HO^- \rightleftarrows$

3.2. – **Give** the expression of the constant K_R of this reaction.

- **Calculate** its value as a function of the given pK_a (H_2O / HO^-)
- **Deduce** that it is complete.

3.3. – **Calculate** the number of moles of C_6H_5COOH and of HO^-

- **Determine** the limiting reactant.

3.4. Knowing that the pH of the obtained solution is calculated by :

$$pH = pK_a (C_6H_5COOH / C_6H_5COO^-) + \log \frac{n_{(C_6H_5COO^-)formed}}{n_{(C_6H_5COOH)remained}}$$

- **Calculate** $n_{(C_6H_5COO^-)formed}$
- **Deduce** the value of the pH of the solution.

Exercise 2: (7 points) **Isoamyl Acetate**

Isoamyl acetate is an ester used in the chemical industry as food aroma.

In the laboratory, it can be prepared according to the reaction of the following word equation:

Ethanoic acid + isoamylic alcohol ⇌ Isoamyl acetate + water

(A) (B) (E)

The aim of this exercise is to identify this ester and to realize its synthesis.

1. Determination of the Structural Formula of Isoamyl Acetate

Given: Molar mass in $g.mol^{-1}$: M(H) = 1; M(C) = 12 ; M(O) = 16.

The structural formula of isoamyl acetate, denoted (E) ,is given in **Document-1:**

$$
\begin{array}{l}
\quad\;\; O \\
\quad\;\; \| \\
CH_3 - C - O - CH_2 - CH_2 - CH - CH_3 \\
\qquad\qquad\qquad\qquad\qquad\quad\; | \\
\qquad\qquad\qquad\qquad\qquad\quad\; R
\end{array}
$$

Where R is an alkyl group of formula C_nH_{2n+1}.

Document-1

The elemental analysis of isoamyl acetate shows that its percentage by mass of oxygen is 24.61 %

1.1. Show that the molar mass of the ester (E) is 130 $g.mol^{-1}$.

1.2.Verify that R is a methyl group of formula CH_3.

1.3.Give the systematic name of the ester (E).

1.4. The isoamylic alcohol (B) can be prepared from the organic compound (C).

The chemical tests in **document-2** are carried out:

N° of test	Reactants	Result
Test 1	Compound (C) + 2,4-D.N.P.H	Positve test
Test 2	Compound (C) + Fehling reagent	Positve test

Document-2

1.4.1. Indicate what do you observe in the two tests (1) and (2).

1.4.2. What information can be drawn out :

- the positive result of test 1.
- the positive result of test 2.

1.4.3. Write, using the condensed structural formulas, the equation of the reaction of preparation of the alcohol (B) starting from the compound (C) (formula of alcohol (B) : $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_2 - CH_2 - OH$).

2. Synthesis of Isoamyl Acetate

Given:

- Density of ethanoic acid: $d_{(ethanoic\ acid)} = 1.05\ g.mL^{-1}$.
- Molar mass of ethanoic acid: $M_{(ethanoic\ acid)} = 60\ g.moL^{-1}$.

A mixture of a volume $V_1 = 30$ mL of ethanoic acid (A) and 0.18 mol of isoamylic alcohol is heated to reflux in the presence of few drops of concentrated sulfuric acid .At an instant t, the number of moles of ester (E) obtained is $n_{(ester)} = 0.14$ mol.

2.1. – **Calculate** the initial mass of ethanoic acid.

- **Show that** the initial number of moles of ethanoic acid is equal to 0.52mol.

2.2. – **Identify** the limiting reactant.

- **Calculate** the maximum number of moles of ester obtained assuming that the reaction is complete.
- **Determine** the yield of this synthesis reaction at the instant of time t.

2.3. Isoamyl acetate can be obtained by replacing ethanoic acid by an acid derivative (D). This compound (D) can be obtained by dehydration reaction of ethanoic acid in the presence of P_2O_5.

2.3.1. Give the condensed structural formula of the compound (D). **Name** it.

2.3.2. Write, using the condensed structural formulas, the equation of the esterification reaction between the compound (D) and the alcohol (B).

2.3.3. List two characteristics of this reaction.

Exercise 3: (7 points) Kinetic Study of The Decomposition of Hydrogen Peroxide

The decomposition of hydrogen peroxide H_2O_2 is a slow reaction and it is represented by the following equation:

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$

The aim of this exercise is to determine the concentration of a hydrogen peroxide H_2O_2 solution (S) and to study the kinetic of its decomposition reaction.

Given : $V_m = 24\ L.mol^{-1}$.

1. Determination of The Concentration of The Solution (S) of H_2O_2

A volume V = 10.0mL of this solution (S) is titrated by an acidified potassium permanganate solution ($K^+ + MnO_4^-$) of concentration $C_1 = 2.0 \times 10^{-2}\ mol.L^{-1}$. The volume of potassium permanganate solution added to reach the equivalence is $V_E = 14.6$ mL.

The equation of the titration reaction is the following:

$$2\,MnO_4^-{}_{(aq)} + 5H_2O_{2(aq)} + 6H_3O^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5O_{2(g)} + 14H_2O_{(l)}$$

1.1. **Indicate** the most precise glassware used to withdraw the volume V :

a. 20 mL **v**olumetric pipet **b.** 10 mL volumetric pipet **c.** 20 mL graduated pipet

1.2. Choose, from the list of **document-1,** the material needed to carry out the titration.

Graduated buret : 25 mL	magnetic stirrer and its bar	
Volumetric flask : 100 mL	beaker : 100 mL	pH-meter

Document-1

1.3. Knowing that the permanganate ion MnO_4^- of violet color is the only colored species, **indicate** how the equivalence point is recognized.

1.4. Show that, the initial concentration of H_2O_2 is: $[H_2O_2]_o = 7.3\times10^{-2}$ mol.L^{-1}.

2. Kinetic Study of The Decomposition Reaction of H_2O_2

100.0 mL of the solution of the hydrogen peroxide solution (S) are decomposed in the presence of few drops of Fe^{3+} ions (catalyst). The hydrogen peroxide is titrated by a solution of potassium permanganate .The appropriate kinetic study leads to the results grouped in the table of **document-2:**

t(min)	0	5	10	20	30	40
$[H_2O_2]$ (10^{-2} mol.L^{-1})	7.3	5.4	4.2	2.3	1.2	0.7

Document-2

2.1. Take the following scales: 1 cm for 5 min in abscissa.

1 cm for 1×10^{-2} mol.L^{-1} in ordinates.

Plot, referring to **document-2,** the curve representing the variation of the concentration of H_2O_2 versus time; $[H_2O_2] = f(t)$ within the interval of time [0 – 40 min] .

2.2. The rate of disappearance of H_2O_2 is determined at two different instants of time. **Match** each rate to its convenient time.

a. t = 0	**i.** $r = 8 \times 10^{-5}$ mol.L^{-1}.min^{-1}
b. t = 30min	**ii.** $r = 6 \times 10^{-3}$ mol.L^{-1}.min^{-1}

2.3. Indicate the kinetic factor responsible for the evolution of the rate of disappearance of H_2O_2 with time.

2.4. – Define the half-life time of the reaction t ½.

- **Determine** graphically this time.

2.5. The kinetic study of the decomposition reaction of H_2O_2 of the same solution (S) is carried out by measuring, using an appropriate method, the volume of the oxygen gas O_2 liberated with time.

2.5.1. – Write the relation between $n(H_2O_2)_{\text{reacted}}$ and $n(O_2)_{\text{formed}}$.

- Knowing that $n_{(O_2)\text{formed}} = \frac{V_{(O_2)t}}{V_m}$, **show that**, at each instant of time t, the concentration of hydrogen peroxide, $[H_2O_2]_t$ expressed in mol.L^{-1}, and the volume of oxygen gas, $V(O_2)_t$ in mL, liberated, are related by the following relation:

$$[H_2O_2]_t = 7.3 \times 10^{-2} - \frac{V_{(O_2)t}}{1200}$$

2.5.2. At a given instant of time the volume of oxygen gas O_2 liberated is 87.6 mL.

Specify whether this instant of time t represents the end of the reaction.