مسابقة في الكيمياء | الاسم:
المدة ســـاعتان | الرقم:

This Exam Includes **Three Exercises**. It Is Inscribed on Four Pages Numbered from **1** to **4**.
The Use of A Non-programmable Calculator Is Allowed.

Answer The Following Three Exercises:

First Exercise (6 points)
Propanoic Acid

This exercise aims to prepare a solution of propanoic acid, which is a weak acid of formula (C_2H_5 – COOH), in order to determine the degree of purity of a sample of magnesium.

Given:

- Molar mass of magnesium: M (Mg) = 24 $g.mol^{-1}$.
- pH range of bromothymol blue: yellow 6.0 – 7.6 blue.

I- Preparation of an Aqueous Solution of Propanoic Acid

Available material list:

* 5 mL, 10 mL and 20 mL volumetric pipets;
* 10 mL, 100 mL and 200 mL graduated cylinders;
* 50 mL, 100 mL and 200 mL beakers;
* 50 mL, 100 mL and 200 mL volumetric flasks;
* A pipet filler.

A volume V_S = 200 mL of solution S of propanoic acid of concentration C_S = 1 $mol.L^{-1}$ is required to be prepared from an aqueous solution of propanioc acid S_0 of concentration C_0 = 10 mol. L^{-1};

1- Find the expression that permits to calculate the volume V_0 of solution S_0 which could be taken for the preparation of solution S. Calculate V_0.
2- Choose, from the above list, the appropriate material for this preparation.

II- Action of Propanoic Acid on Magnesium

A volume V = 50 mL of solution S, to which few drops of bromothymol blue has been added, is introduced into a beaker containing 0.45 g of a sample of magnesium. The propanoic acid attacks the magnesium by giving hydrogen gas and magnesium propanoate which is soluble in water. The remaining solution is still yellow at the end of the reaction.

1- Show that magnesium reacts completely.
2- Write the equation of the reaction that takes place in the beaker.

III- Determination of the Percentage of Magnesium In the Sample

The steps below are carried out in order to determine the degree of purity of magnesium in the sample:

- Filtration of the remaining solution at the end of the reaction in part **II**.
- Removal of impurities and magnesium ions Mg^{2+} from the filtrate.

- Titration of the acid in the filtrate with a sodium hydroxide solution of concentration C_b = 0.5 mol. L^{-1}. The equivalence point is reached when the added volume of the basic solution is V_{bE} = 32.5 mL.

1- Write the equation of the titration reaction.
2- Determine the number of moles of the acid in the filtrate.
3- Calculate the number of moles of the acid reacting with magnesium.
4- Deduce the percentage by mass of magnesium in the used sample.

Second Exercise (7 points)
Decomposition of Javel Water

Javel water is an aqueous solution containing the following ions: hypochlorite ClO^-, chloride Cl^- and sodium Na^+. It is very often used as a disinfectant due to the oxidizing character of the hypochlorite ions.
Javel water decomposes very slowly according to the reaction of the following equation:

$$2\ ClO^-_{(aq)} \rightarrow 2\ Cl^-_{(aq)} + O_{2\,(g)}.$$

This reaction could be accelerated by light or by using a catalyst of a cobalt compound such as cobalt (II) chloride ($CoCl_2$).

Given:

- Take molar volume of gas: V_m = 24 L.mol^{-1}.

I- Decomposition of Javel Water

In order to study the kinetic of the decomposition reaction of Javel water, at the instant when the cobalt ions Co^{2+} are introduced into a volume V = 110 mL of Javel water solution called (S), the volume of the obtained oxygen gas is measured.
The concentration of the remaining ions (ClO^-) in the solution (S) at each instant t is then deduced. The results are given in the following table:

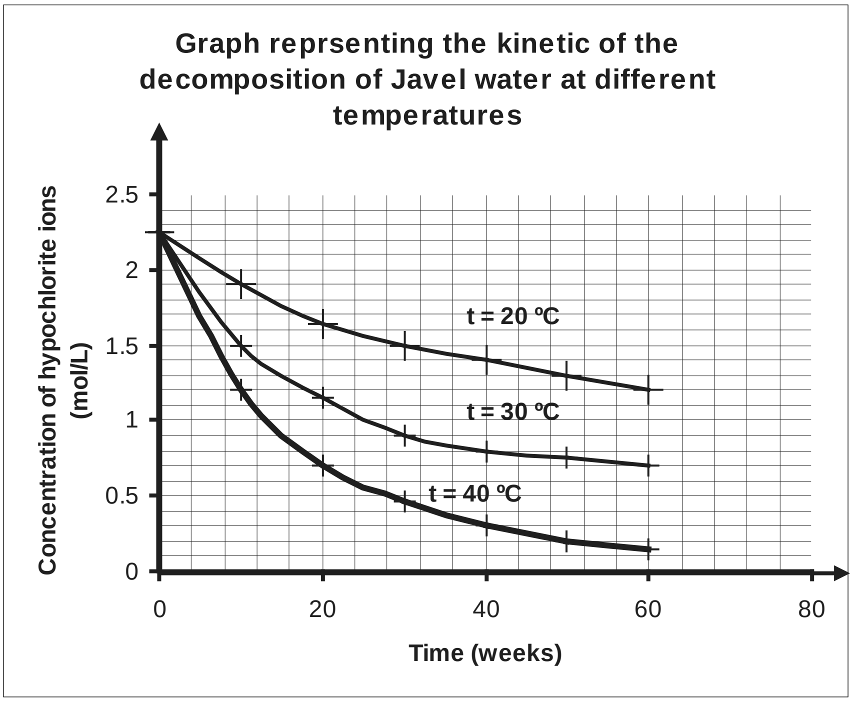
t (s)	0	30	60	90	120	150	180	210	240	300
[ClO^-] mol.L^{-1}	0.24	0.20	0.17	0.14	0.12	0.10	0.080	0.060	0.046	0.026

1- Plot, on a graph paper, the curve representing the variation of [ClO^-] versus time. Take the following scales:
abscissa: 1 cm for 30 s; ordinate: 1 cm for 0.02 mol.L^{-1}.
2- Determine the rate of disappearance of ClO^- at instant t = 210 s
3- Knowing that the rate of disappearance of ClO^-, at instant t = 0, is 1.6×10^{-3}mol.L^{-1}.s^{-1}, identify the kinetic factor that is responsible for the variation of this rate with time.
4- Determine, graphically, the half-life of the reaction $t_{½}$.
5-
a) Show that that the concentration of hypochlorite ions $[ClO^-]_t$, in mol.L^{-1}, and the volume of oxygen gas $V(O_2)_t$, in mL, at instant t, are related by the following relation: $[ClO^-]_t = 0.24 - 7.57\times10^{-4} \times V(O_2)_t$.
b) Identify the chemical speices which are present in the solution (S) when the volume $V(O_2)$ = 317 mL.

II- Stability and Precautions of Use

Among the recommendations on the label of a bottle of Javel water it is written: ″store in cold place without exposure to sun and light ″.
The graph below shows the progress of the decomposition reaction of Javel water at different

temperatures.



Referring to the above graph, justify the recommendation ˝ stored in cold place without exposure to sun …˝.

Third Exercise (7 points)
Saponification Reaction

This exercise aims to prepare soap by two processes and to study the principle of detergency of soap.

<u>Given</u>:

- Molar masses in g.mol^{-1}: palmitic acid: M_1 = 256; sodium palmitate: M_2 = 278.

I- Saponification of Glyceryl Palmitate

Glyceryl palmitate is the triester of palmitic acid ($C_{15}H_{31} – COOH$) and glycerol ($CH_2OH – CHOH – CH_2OH$).
Saponification is a reaction between fatty substances (fats and oils) with sodium hydroxide (or potassium hydroxide). It is represented by the following equation:

$$\begin{array}{l} CH_2 – O – CO – R_1 \\ | \\ CH – O – CO – R_2 \\ | \\ CH_2 – O – CO – R_3 \end{array} + 3\ NaOH \rightarrow \begin{array}{l} CH_2 – OH \\ | \\ CH – OH \\ | \\ CH_2 – OH \end{array} + R_1COONa + R_2COONa + R_3COONa$$

1- Write the equation of the saponification reaction between the glyceryl palmitate and

sodium hydroxide.
2- Give the systematic name of the obtained alcohol (glycerol).
3- Among the following terms: fast, slow, complete, reversible and impossible, choose those that characterize this saponification reaction.

II- <u>Industrial Preparation of Soap</u>

Soap could be prepared by the continuous process, designated as the hydrolysis process. By this process, fatty acids are prepared by the hydrolysis of the appropriate lipids and oils, under pressure and high temperature. These acids are separated from glycerol and purified, and then made to react with sodium hydroxide to obtain soap and water.
The above process is used to prepare the soap from 1 ton of beef fat.

1- Write the equation of the hydrolysis reaction of glyceryl palmitate.
2- Write the equation of the reaction between palmitic acid and sodium hydroxide.
3- Calculate the number of moles of the obtained palmitic acid, knowing that the mass of this acid issued from beef fat is equal to 25 % of the mass of the beef fat.
4- The obtained soap (sodium palmitate) has a mass of 250 kg. Determine the yield of this preparation of soap.

III- <u>Structure of carboxylate ion</u>

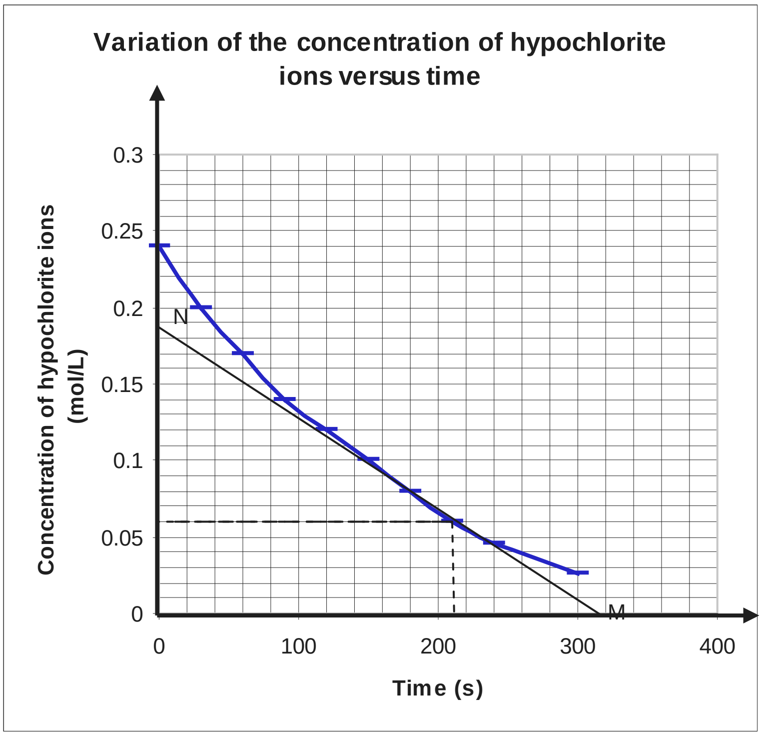
Carboxylate ion ($R - COO^-$) of soap is formed of two parts, the hydrocarbon chain ($R -$) and the carboxylate group ($- COO^-$).

1- Give the meaning of the two terms: hydrophilic and hydrophobic.
2- Indicate, in the carboxylate ion, the part that corresponds to the hydrophilic group and that part that corresponds to the hydrophobic group.
3- Specify the role of the structure of the carboxylate ion in the cleaning process by soap.

First Exercise (6 points)
Propanoic Acid

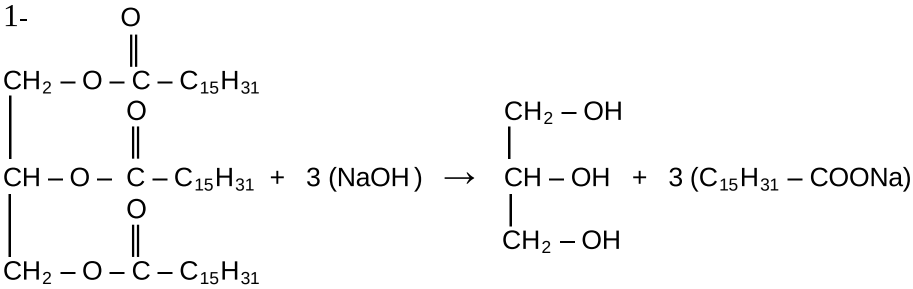
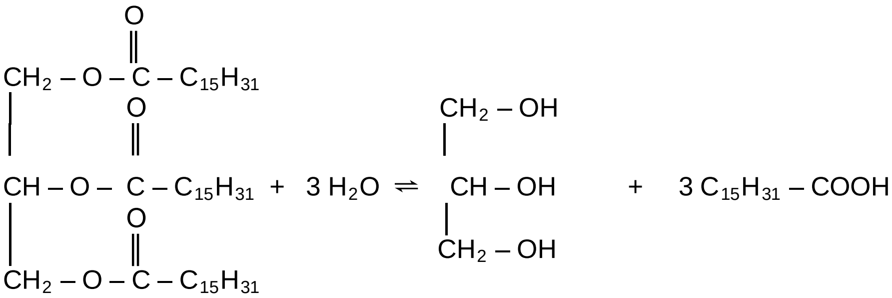
Expected Answer	Mark	Comment
I- Preparation of an aqueous solution of propanoic acid		
1- By dilution the number of moles of solute dose not change, that	0.25	
allows to write: n = $C_0 x V_0 = C_S x V_S$. where: $\mathbf{V_0} = \frac{C_S x V_S}{C_0}$.	0.25	
$\mathbf{V_0} = \frac{1x200}{10}$ **= 20 mL**.	0.25	
2- The material used to carry out this preparation Includes: a 20 mL volumetric pipet, 200 mL volumetric flask, pipet filler and a beaker.	0.5	0 without pipet or volumetric flask
II-Action of propanoic acid on magnesium		
1- Since the solution is still yellow at the end of the reaction this means that the medium is acidic because the BBT gives a yellow color when the pH is acid. Thus, we conclude that the magnesium reacted completely .	075	
2-The equation of the reaction that takes place in the beaker is: $2\ CH_3 - CH_2 - COOH + Mg \rightarrow 2\ CH_3 - CH_2 - COO^- + Mg^{2+} + H_{2\,(g)}$.	0.5	
III-Determination of the percentage of magnesium in the sample		
1- The equation of the titration reaction is: $CH_3 - CH_2 - COOH + HO^- \rightarrow CH_3 - CH_2 - COO^- + H_2O$	0.5	
2- At the equivalence point, the number of moles of acid in the beaker is equal to the number of moles of HO^- added. So the number of moles of the titrated acid is:	0.25	
$n_{titrated} = C_b\ (mol.L^{-1})\ xV_{bE}\ (L) = 0.5x32.5x10^{-3} = \mathbf{16.25x10^{-3}\ mol}$.	0.75	
3- The number of moles of acid reacting with magnesium is given by: $n = n_0 - n_{titrated} = C_S x V_{(L)} - n_{titrated} = 1x50x10^{-3} - 16.25x10^{-3}$.	0.75	
Where: n = $\mathbf{33.75x10^{-3}\ mol}$.		
4- The percentage by mass of magnesium in the sample is given by: $\frac{m_{(Mg)} x100}{m_{minerai}} = \frac{n_{(Mg)} x M_{(Mg)} x100}{m_{(minerai)}}$	1.25	
According to the equation, we have: $n_{(Mg)\ reacting} = \frac{n_{(acid)reacting}}{2} = \frac{n}{2} = 16.875x10^{-3}$ mol.		
The percentage is then: $\frac{16.875x10^{-3} x24x100}{0.45} =$ 90%.		

Second Exercise (7 points)
Decomposition of Javel Water

Expected Answer	Mark	Comment
I-Decomposition of Javel water 1- The curve representing the variation of $[CLO^-]$ versus time: 	1.25	
2- The rate of disappearance of ClO^- $r = -\frac{d[ClO^-]}{dt}$; is equal to the negative slope of the tangent to the curve at instant t=210s Calculation of the rate : M & N are two points on the tangent of coordinates M(320-0) and N(0-0.19). So $r = -\frac{0-0.19}{320-0} = 5.9x10^{-4}$ $mol.L^{-1}.S^{-1}$.	1.25	
3- Rate at $t=_0$> rate at $t=_{210}$, the rate decreases with time. The factor that is responsible for this decrease is the concentration of hypochlorite ions that lead to reduce the rate.	0.5	
4- The half-life of the reaction is the time needed for half the concentration of $[ClO^-]_0$ to disappear. It becomes 0.12 $mol.L^{-1}$ at time $t_{1/2}$ = 138 s.	1	
5- a) $[ClO^-]_t = \frac{n(ClO^-)_t}{V(solution)_L} = \frac{n_0 - n_{reacting}}{V} = [ClO^-]_0 - \frac{2n(O_2)_{formed}}{V}$ $[ClO^-]_t = 0.24 - \frac{2xV(O_2)_t}{24x10^3x110x10^{-3}}$ = **0.24 – 7.57x10^{-4}xV(O_2)$_t$**.	1	
b) For a volume $V(O_2)_t$ = 317 mL we have: $[ClO^-]_t$ = 0. This means that the hypochlorite ions reacted completely and the species that are present in the solution other than water are the ions: chloride and cobalt.	1	
III- The graph shows that the increase in temperature accelerates the rate of the decomposition of hypochlorite ions. This leads to a decrease in the	1	

concentration of the hypochlorite ions that reduces its disinfecting power. Thus, Javel water should be stored away from heat sources like sun …; that justifies this recommendation.		

Third Exercise (7 points)
Saponification Reaction

Expected Answer	Mark	Comment
I- 1- 	1	
2- It is the 1,2,3-tripropanol.	0.25	
3- The saponification reaction is slow and complete.	0.5	
II- 1- The equation of the reaction is: 	1	
2 The equation of the reaction is: $C_{15}H_{31}-COOH + NaOH \rightarrow C_{15}H_{31}-COONa + H_2O$	0.5	
3- The number of moles palmitic acid is: n = $\frac{m(acid)}{M(acid)} = \frac{m(tallow)x25}{M(acid)x100} = \frac{10^6 x25}{256x100}$ = **976.56 mol**.	0.75	
4- The yield R = $\frac{n(soap)_{obtained}}{n(soap)_{theoric}} x100$. $n_{theoric} = n_{acid}$ et $n_{obtained} = \frac{m(soap)}{M(soap)}$; where: R = $\frac{250x10^3}{278x976.56}$ x100 = **92 %**.	1.5	
III- 1- Hydrophilic means water loving; hydrophobic means water hating.	2x0.25	
2- The hydrocarbon group (R –) is hydrophobic and the group ($-COO^-$) is hydrophilic.	2x0.25	
3- This structure offers to carboxylate ions of soap the hydrophilic and hydrophobic characters which are at the base of the solubility of the soap in water and in lipids that facilitates its cleaning power.	0.5	