LEBANESE UNIVERSITY
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Entrance Exam (2018 – 2019) **Chemistry Exam** **Duration: 1 h**
8 July 2018

Answer the Following three Exercises:

Exercise 1 (7 points)
Identification of Organic Compounds

Consider the succession of the reactions of the organic compounds (A), (B), (C) and (D) which correspond to the following equations:

$A \xrightarrow[350^0C]{Cu} B + H_2$ (1)

$B + \frac{1}{2}O_2 \rightarrow C$ (2)

$C + PCl_5 \rightarrow D + POCl_3 + HCl$ (3)

$D + A \rightarrow C_6H_{12}O_2 + HCl$ (4)

$C + A \leftrightarrows C_6H_{12}O_2 + H_2O$ (5)

1- Determine the number of carbon atoms in the molecules of (A), (C) and (D).
2- A sample of (B) gives a positive test with Fehling solution. Specify the functional groups of (A), (B) and (C).
3- Write the condensed structural formulas and give the names of (A), (B) and (C).
4- Write, using the condensed structural formulas the equations of the reactions (4) and (5).
5- The two following experiments are carried out: in the first one (I) 1 mol of (A) and 1 mol of (D) are mixed and in the second experiment (II) 1 mol of (A) and 1 mol of (C) are mixed.
The table below represents the two experiments I and II:

Experiment	$n_{A\ initial}$	$n_{C\ initial}$	$n_{D\ initial}$	$n\ C_6H_{12}O_2\ formed$
I	1mol	-	1mol	About 1 mol
II	1mol	1mol	-	About 0.66 mol

Interpret.

Exercise II (7 points)
Acid-base Solutions

Consider, at 25 ºC, the two following solutions: solution (A) of hydrochloric acid of concentration $C_A = 2.0\times10^{-2}$ mol.L^{-1} and solution (B) of sodium hydroxide of concentration $C_B = 1.0\times10^{-2}$ mol.L^{-1}.
1-Determine the pH of (A) and that of (B).
2- It is required to prepare a solution (C) of pH = 2.7, starting from a volume V_A of solution (A) and a volume V_B of solution (B).
2.1- Write the equation of the reaction that took place in this mixture.
2.2- What has to be the reagent in excess? Justify.
2.3- In which ratio it is necessary to mix V_A and V_B?

Exercise III (6 points)
Effect of the Concentration of a Reagent on the Reaction Rate

To study the effect of the initial concentration of a reagent on the rate of a chemical reaction, a solution of potassium peroxodisulfate ($K_2S_2O_8$) and a solution of potassium iodide (KI) are mixed into a beaker at the bottom of which a letter was drawn. A brown coloring, due the formation of diiode (iodine), appears slowly according to the following equation:

$$S_2O_8^{2-} + 2\,I^- \rightarrow 2\,SO_4^{2-} + I_2$$

The iodine can be highlighted by the blue coloring which is gives with starch paste. Δt is the duration of the reaction by time with the end of which the blue coloring masks the letter (the blue coloring that masks the letter corresponds to identical concentrations for all the reaction mediums).
Experimental data:

Nº of the experiment	1	2	3	4	5
V_1 = volume (mL) of $K_2S_2O_8$ solution of concentration $C_1 = 1.0\times10^{-2}$ mol.L^{-1}	40	32	24	16	8
V_2 = volume (mL) of distilled water	0	8	16	24	32
V_3 = volume (mL) of starch paste	1	1	1	1	1
V_4 = volume (mL) of KI solution of concentration C_2 = 1 mol.L^{-1}	4	4	4	4	4
Duration Δt (seconde)	99	119	160	240	526
Concentration $[S_2O_8^{2-}]_0$ (10^{-3} mol.L^{-1})	8.88	7.11		3.55	1.77
$\frac{1}{\Delta t}$ (10^{-3} s^{-1})	10	8.4		4.16	1.9

1- Establish the relation that gives the value of the initial concentration of $S_2O_8^{2-}$.
2- Calculate the two missing values in the above table.

3- Plot the graphic representation of the function: $\frac{1}{\Delta t} = f[S_2O_8^{2-}]$. Take the following scale:
Abscissa: 1 square = 1.0×10^{-3} mol.L^{-1}; Ordinate: 1 square = $1,0\times10^{-3}$ s^{-1}.

4- Deduce that the average rate of formation of iodine is proportional to the initial concentration of $S_2O_8^{2-}$.

Entrance Exam (2018 – 2019) **Chemistry Solution** **8 July 2018**

Exercise 1 (7 points)
Identification of Organic Compounds

1- The succession of the reactions shows that (A), (B), (C) and (D) have the same number of carbon atoms in their formulas which is 3 atoms.
The equation of the reaction 4 (or that of the reaction 5) shows that the full number of carbon atoms in the molecules of (A) and (D) is 6. Thus we draw that the number of carbon atoms in the molecules of (A), (B), (C) and (D) is 3.

2- (B) is an aldehyde because it gives a positive test with the Fehling solution (functional group – CHO) ; it is obtained from the mild oxidation of a primairy alcohol which is (A) (group hydroxyle – OH) and it gives by oxidation a carboxylic acid (C) (group carboxyle – COOH).

3- (A): $CH_3 – CH_2 – CH_2OH$: 1-propanol;
(B): $CH_3 – CH_2 – CHO$: propanal;
(C): $CH_3 – CH_2 – COOH$: propanoic acid.

4- $CH_3 – CH_2 – COCl + CH_3 – CH_2 – CH_2OH \rightarrow CH_3 – CH_2 – COO – CH_2 – CH_2 – CH_3 + HCl$. $CH_3 – CH_2 – COOH + CH_3 – CH_2 – CH_2OH \rightleftharpoons CH_3 – CH_2 – COO – CH_2 – CH_2 – CH_3 + H_2O$.

5- The mixture in (I) causes a complete reaction between acyle chloride and 1-propanol which leads to the formation of 1 mol of ester from 1 mol of acyle chloride and 1 mol of alcohol. While the reaction between 1 mol of propanoic acid and 1 mol of 1-propanol in mixture (II) leads to the formation 0f 0.66 mol of ester because this reaction is incomplete.

Exercise 2 (7 points)
Acid-base Solutions

1- At 25 ºC we have: for a strong monoacid pH = - log Ca and for a strong monobase pH=14+logCb. Where: pH(A) = $- \log 2\times10^{-2} = 1.7$ and pH(B) = $14 + \log 1.0\times10^{-2} = 12$.

2-

2.1- $H_3O^+ \;+\; HO^- \;\rightarrow\; 2\,H_2O$.

2.2- The pH of (C) = 2.7 <7 is clearly acid, acid (A) is then the reagent in excess.

2.3- From the pH = 27 we obtain $[H_3O^+]= 2.10^{-3}$ mol.L^{-1}.

$n(H_3O^+)_{\text{in excess}} = n(H_3O^+)_{\text{initial}} - n(H_3O^+)_{\text{reacting}} = C_AV_A - C_BV_B$

$$[H_3O^+] = \frac{C_AV_A - C_BV_B}{V_A + V_B}$$

$$2.10^{-3} = \frac{0.02V_A - 0{,}01V_B}{V_A + V_B}.\ \text{With } \frac{V_A}{V_B} = x\ .$$

$$0.002 = \frac{0.02\,x - 0{,}01}{x+1}.\ \text{We obtain } x = \frac{2}{3}.$$

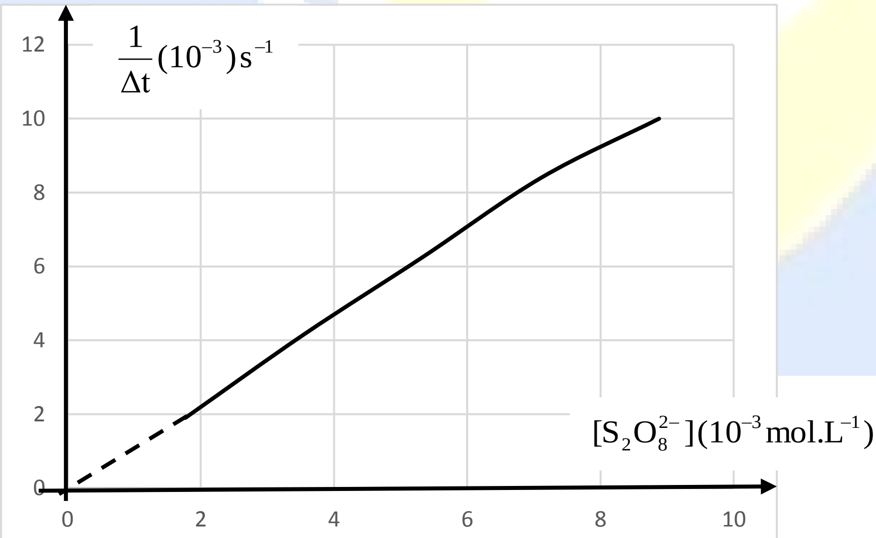
Exercise 3 (6 points)

Effect of the Concentration of a Reagent on the Rate of the Reaction

1- $[S_2O_8^{2-}]_I = \dfrac{n(S_2O_8^{2-})_{\text{initial}}}{V_{\text{total}}} = \dfrac{C_1V_1}{V_1+V_2+V_3+V_4} = \dfrac{1.0\times10^{-2}\,V_1}{45}$ mol.L^{-1}.

2- The two missing values are respectively: 5.33 (5.33×10^{-3}) et 6.25 (6.25×10^{-3}).

3- La courbe :



4- The curve $\frac{1}{\Delta t} = f[S_2O_8^{2-}]$ is a segment of line, which by extrapolation passes by the origin, shows that this fraction $\frac{1}{\Delta t}$ is proportional to the concentration of peroxodisulfate. However the average rate of formation of I_2:
$v(I_2) = \frac{\Delta[I_2]}{\Delta t} = \frac{\text{Constant}}{\Delta t} = \text{constant} \times f[S_2O_8^{2-}]$ is inversely proportional to the duration Δt thus proportional to $[S_2O_8^{2-}]$.