| الاسم: | مسابقة في مادة الكيمياء |
| الرقم: | المدة: ساعة ونصف |

يتكون هذا الامتحان من خمسة تمارين موزّعة على ٦ صفحات. يجب اختيار ثلاثة تمارين فقط.

اقرأ الاسئلة كلها بشكل عام وشامل ، ومن ثم حدّد اختياراتك.

ملاحظة: في حال الإجابة عن أكثر من ثلاثة تمارين ، عليك شطب الإجابات المتعلقة بالتمارين التي لم تعد من ضمن اختيارك، لأن التصحيح يقتصر على إجابات التمارين ، الثلاث الأولى غير المشطوبة، بحسب ترتيبها على ورقة الإجابة. يمكن الاستعانة بالآلة الحاسبة غير القابلة للبرمجة. تُلحظ نصف علامة لتنسيق المسابقة.

Answer Three Exercises from the Following:

Exercise 1 (6.5 points)   **Titration of a Strong Base**

Available is a commercial solution of a household product containing sodium hydroxide denoted as (S_o) as shown in **Document-1**.

Solution (S_o)
Household solution containing sodium hydroxide
% by mass of NaOH = ?   d = 1.27 g.mL^{-1} M $_{(NaOH)}$ = 40 g.mol^{-1}

Document-1

The aim of this exercise is to determine the percentage by mass of NaOH in this household product.

1. Preparation of a Solution (S_1)

A sodium hydroxide solution (S_1) is prepared by diluting 100 times the commercial solution (S_o).

Choose, from **Document-2**, the most appropriate set for the preparation of solution (S_1). Justify.

Set 1	**Set 2**	**Set 3**
Beaker of 100 mL	Beaker of 100 mL	Beaker of 100 mL
Volumetric Pipet of 5mL	Graduated Pipet of 5mL	Volumetric Pipet of 10 mL
Erlenmeyer Flask of 1000 mL	Volumetric Flask of 250 mL	Volumetric Flask of 500 mL

Document-2

2. pH-metric Titration of Solution (S_1)

A volume $V_b = 20.0$ mL of the sodium hydroxide $(Na^+ + HO^-)$ solution (S_1) of molar concentration C_b 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 hydrochloric acid solution $(H_3O^+ + C\ell^-)$ of molar concentration $C_a = 7.5 \times 10^{-2}$ mol.L^{-1}. The volume of the acid solution added to reach equivalence is $V_{aE} = 21.2$ mL.

2.1. Name the glassware used to:
2.1.1. Withdraw the volume V_b of the sodium hydroxide solution.
2.1.2. Add the hydrochloric acid solution.
2.2. Write the equation of the titration reaction.

2.3. Justify, based on the chemical species present, that the solution at equivalence is neutral.
2.4. Determine the molar concentration C_b of sodium hydroxide in the solution (S_1).
2.5. Show that the molar concentration of the commercial solution (S_o) is $C_o = 7.95$ mol.L^{-1}
      2.6. Deduce the percentage by mass of NaOH in the commercial solution.
2.7. Specify whether the following statements are correct or false:
      2.7.1. The initial value of pH of the solution in the beaker decreases with the addition of distilled water.
      2.7.2. The pH of the solution tends to zero upon the addition of a large volume of the hydrochloric acid solution.

Exercise 2 (6.5 points)   **Identification and Preparation of an Organic Compound**

A mono-functional organic compound, noted as (A), with a saturated non-cyclic carbon chain is used as a food additive to give fruit flavor to various food products.
The aim of this exercise is to identify the compound (A) and to study its preparation reaction from a suitable chosen organic compound.

Given:

- Molar atomic masses in g.mol^{-1} : M(H) = 1 ; M(C) = 12 ; M(O) = 16
- The density of organic compound (A): d(A) = 0.80 g.mL^{-1}.
- Compound (A) is liquid at room temperature.

1. Identification of the Organic Compound (A)
   1.1. To identify the chemical family to which compound (A) belongs, two experimental tests are carried out. The results of the two tests are shown in the table of **Document-1**.

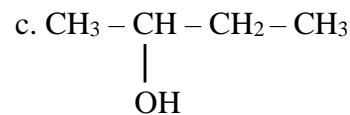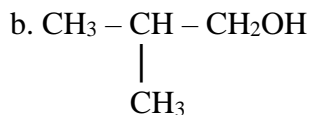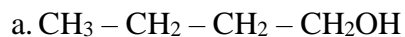| Test number	Experimental Test	Results
1	Compound (A)+ 2,4 - DNPH	Yellow orange precipitate
2	Compound (A) + Ammonical silver nitrate solution (Tollen's reagent)	Silver mirror
Document - 1		

   1.1.1. Specify, based on the results of the two tests of **Document-1**, the family to which compound (A) belongs.
   1.1.2. Choose the general formula of compound (A):
   a- $C_nH_{2n}O_2$ b- $C_nH_{2n+2}O$ c- $C_nH_{2n}O$
   1.2. At room temperature, 1 mol of the compound (A) occupies a volume V = 90.0 mL.
      1.2.1. Verify that the molar mass of the compound (A) is M = 72 g.mol^{-1}.
      1.2.2. Deduce that the molecular formula of the compound (A) is C_4H_8O.
   1.3. Identify the compound (A) knowing that its carbon chain is branched.
   1.4. Answer, by justifying, with true or false.
      2- butanone is an isomer of the compound (A).
2. Preparation of the Compound (A)
The compound (A) can be prepared by mild oxidation, in the presence of oxygen gas (O_2), of an organic compound denoted as (B).

   2.1. Choose, among the following condensed structural formulas, the one that corresponds to compound (B). Justify.

a. $CH_3 – CH_2 – CH_2 – CH_2OH$　　　　b. $CH_3 – CH – CH_2OH$　　　　c. $CH_3 – CH – CH_2 – CH_3$

　　　　　　　　　　　　　　　　　　　　　　　　　|　　　　　　　　　　　　　　　|

　　　　　　　　　　　　　　　　　　　　　　　CH_3　　　　　　　　　　　OH

2.2. Write, using condensed structural formulas, the equation of the reaction of this preparation.

2.3. The mild oxidation of the organic compound (B) leads to the formation of an organic compound other than compound (A). Identify this compound.

Exercise 3 (6.5 points)　　　　　　**A Study of an Organic Compound (E)**

Flavoring agents are substances added to food or drinks to enhance or modify their taste, aroma, or texture. Artificial flavorings are often made using chemicals or synthetic compounds.

Available is a saturated non-cyclic chain mono-functional organic compound (E) of general formula $C_nH_{2n}O_2$.

The aim of this exercise is to identify the compound (E) and to study its synthesis reaction.

Given:

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

1. **Identification of the Compound (E)**

   The elemental analysis of the compound (E) shows that the percentage by mass of oxygen in this compound is: **%O = 31.37 %**

   1.1. Show that the molecular formula of the compound (E) is $C_5H_{10}O_2$.
   1.2. Give the possible chemical families of the compound (E).
   1.3. The reaction of the organic compound (E) with water produces two organic compounds: methanoic acid and a compound (A). Deduce the chemical family of the compound (E).
   1.4. Justify that the molecular formula of the compound (A) is $C_4H_{10}O$.
   1.5. Choose the possible condensed structural formula(s) of the compound (E), knowing that the carbon chain of the compound (A) is a non-branched chain.

|		
O ‖ H— C – O – CH$_2$ – CH$_2$ – CH$_2$ – CH$_3$	O ‖ H— C – O – CH$_2$ – CH – CH$_3$ 　　　　　　　　　｜ 　　　　　　　　CH$_3$	O ‖ H— C – O – CH – CH$_2$ – CH$_3$ 　　　　　　｜ 　　　　　CH$_3$
i	**ii**	**iii**

1.6. The compound (A) is a secondary alcohol.

　1.6.1. Identify compound (E).

　1.6.2. Write, using condensed structural formulas, the equation of the reaction of the compound (E) with water.

2. **Synthesis of the Ester (E)**

A reaction mixture is prepared by mixing 0.1 mol of methanoic acid and 0.1 mol of compound (A) with a few drops of concentrated sulfuric acid (catalyst). The reaction mixture is heated to reflux for a certain time to reach equilibrium. An ester (E) is formed according to the esterification reaction of equation:

(A) + methanoic acid $\rightleftharpoons$ (E) + water
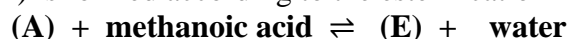
The obtained mass of compound (E) is at equilibrium 6.12 g.

2.1. Give the importance of reflux heating.

2.2. Determine the yield of this reaction.
2.3. Another reaction mixture is prepared by mixing 0.2 mol of methanoic acid and 0.2 mol of compound (A) with a few drops of concentrated sulfuric acid (catalyst). The reaction mixture is heated to reflux for a certain time to reach equilibrium Choose, by justifying, the obtained mass m′ of compound (E) at equilibrium:
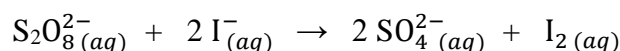
a- m′= 6.12 g   b- m′ = 12.24 g   c- m′= 3.06 g

Exercise 4 (6.5 points)   **Kinetic Study of a Slow Reaction**

The reaction between iodide ions and peroxydisulfate ions is slow and complete and represented by the following equation:

$$S_2O_8^{2-}{}_{(aq)} \ + \ 2\,I^-_{(aq)} \ \rightarrow \ 2\,SO_4^{2-}{}_{(aq)} \ + \ I_{2\,(aq)}$$

The aim of this exercise is to study the kinetics of this slow reaction at a constant temperature T.
In order to study the kinetics of this reaction, introduce, at instant $t = 0$, into a beaker:

- A volume $V_1 = 100$ mL of potassium iodide solution $(K^+ + I^-)$ of molar concentration $C_1= 0.8$ mol.L^{-1}
- A volume $V_2 = 100$ mL of sodium peroxydisulfate $(2Na^+ + S_2O_8^{2-})$ of molar concentration $C_2 = 0.2$ mol.L^{-1}.

The reaction system is maintained at a constant temperature T.

1. Preliminary Study

1.1. Show that the initial molar concentrations of iodide ions and peroxydisulfate ions are respectively
$[I^-]_o = 0.4$ mol.L^{-1} and $[S_2O_8^{2-}]_o= 0.1$ mol.L^{-1}
1.2. Verify the following relation: $[I^-]_{t_{1/2}} = [I^-]_o - [I_2]_\infty$
where $[I^-]_{t_{1/2}}$ is the molar concentration of iodide ions at t ½ , $[I^-]_o$ is the initial molar concentration of iodide ions and $[I_2]_\infty$ is the molar concentration of iodine at the end of the reaction.

2. Kinetic Study

In order to determine the concentration of iodine $[I_2]$ at instant t, a volume of the reaction mixture is taken and poured into an Erlenmeyer flask containing ice water. The iodine formed is titrated with a sodium thiosulfate solution $(2Na^+ + S_2O_3^{2-})$.

The results obtained allow us to determine the concentrations of iodide ions, $[I^-]_t$, at different instants t. The table of **Document-1** represents the evolution of the concentration of iodide ions, $[I^-]$ as a function of time.

t (min)	0	10	20	30	40	50	60	70	80
$[I^-]\,10^{-3}$ mol.L^{-1}	400	300	270	248	232	218	206	200	200

Document-1

2.1. Plot the curve that represents the variation of the concentration of iodide ions,$[\,I^-]$, as a function of time, $[I^-] = f(t)$ within the interval of time $[0 – 80$ min].
Take the following scales: abscissa: 1 cm for 10 min; ordinate: 1 cm for 40×10^{-3} mol.L^{-1}.
2.2. Verify, graphically, that iodide ions (I^-) are in excess.
2.3. Determine the concentration of iodine at the end of the reaction, $[I_2]_\infty$.
2.4. Calculate the concentration of iodide ions at t ½ , $[I^-]_{t\,1/2}$.
2.5. Deduce, graphically, the half-life time t ½ of this reaction.

3. Kinetic Factors

The previous experiment is repeated but with **only one modification**: one introduces, without changing the total volume, a few drops of a catalyst (iron III ions solution).

- Choose, from the curves of **Document-2**, the one that represents the evolution of the concentration of iodine in the presence of catalyst $[I_2] = g(t)$. Justify.

Document-2
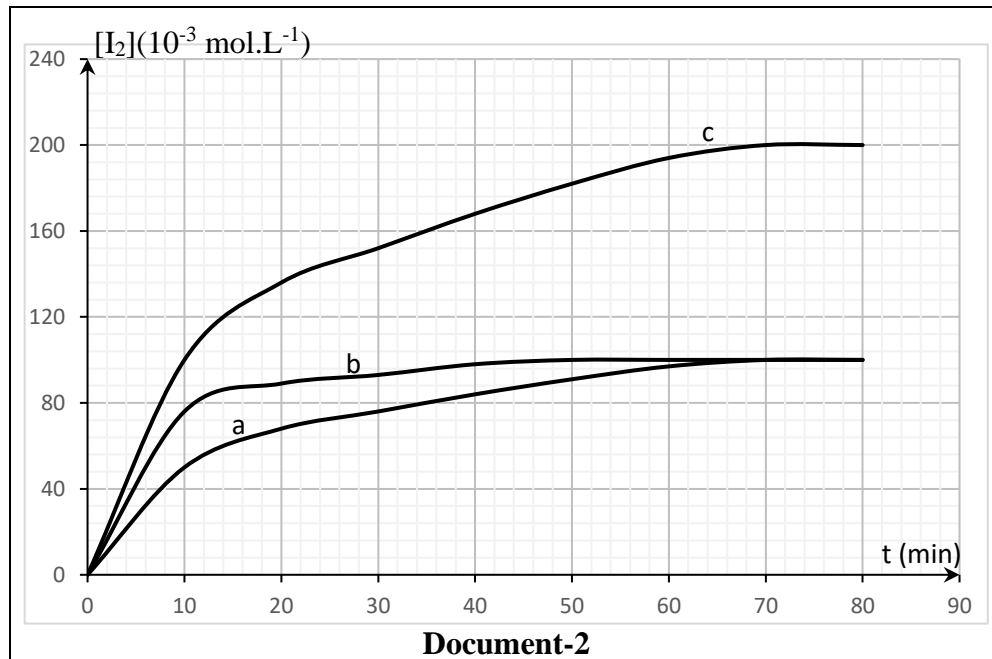
Exercise 5 (6.5 points)   Study of a commercial Ammonia Solution

Available is a commercial ammonia solution. The aim of this exercise is to determine the molar concentration of ammonia in this solution and to study its behavior.

Given:
- The study is carried out at $T = 25°C$
- The ion product of water is: $K_w = 10^{-14}$

1. **Preliminary study**

The label of a bottle containing a commercial household solution, denoted (S_o), shows among others the following indications: % by mass of ammonia $NH_3 = 5.25\%$; density d= 0.976 $g.mL^{-1}$; $M(NH_3) = 17$ $g.mol^{-1}$

Show that the molar concentration of this commercial solution is $C_o = 3$ $mol.L^{-1}$.

2. **Behavior of Base NH_3 in water**

The commercial ammonia solution (S_o) is diluted in order to prepare solution (S) of molar concentration $C_b = 6 \times 10^{-2}$ $mol.L^{-1}$. The pH of solution (S) is equal to 10.99
   2.1. Verify that NH_3 is a weak base.
   2.2. Write the equation of the reaction between NH_3 and water.

2.3. Verify that K_a of the conjugate acid/base pair (NH_4^+/ NH_3) is 6.3×10^{-10} ($[NH_4^+]$ is neglected compared to the concentration C_b).

2.4. Choose, from the following, the pH of an ammonia solution (S′) of molar concentration 6×10^{-4} mol.L^{-1}. Justify.

    a- pH=9.95   b- pH = 12.04   c- pH =8.99

3. Degree of conversion of the weak base NH_3

3.1. Establish the following relation: $\alpha = \dfrac{10^{pH-14}}{C}$ knowing that α is the degree of conversion of ammonia NH_3 and C is the molar concentration of ammonia solution.

3.2. Given the table of **Document-1.**

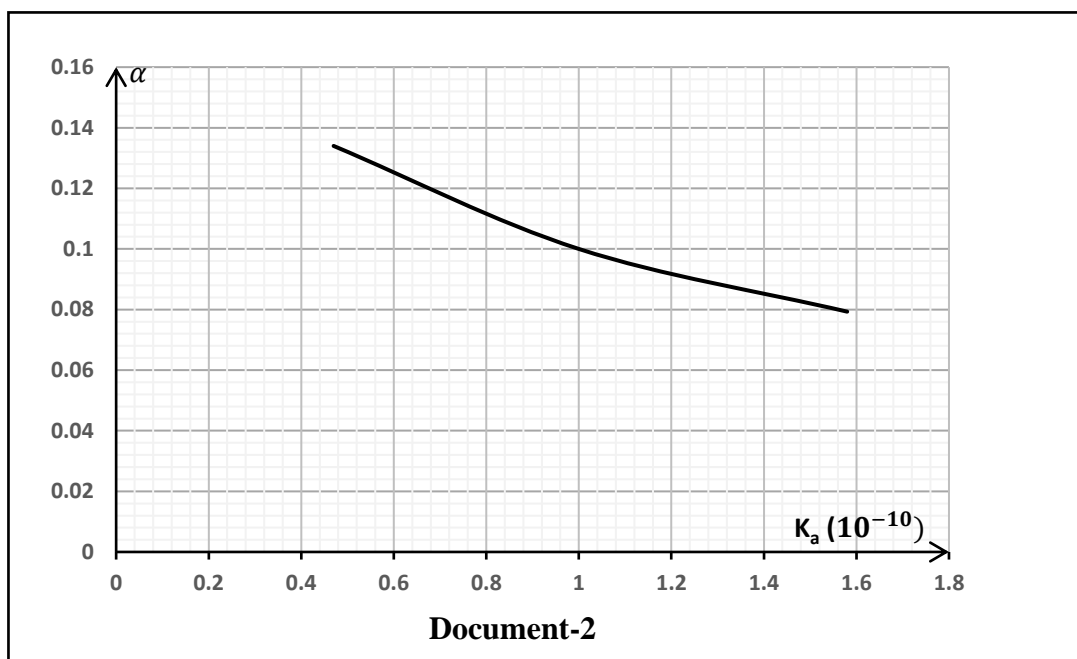| Solution	(S)	(S′)
Degree of conversion	$\alpha = 0.016$	α'

Document-1

    3.2.1. Calculate α'.

    3.2.2. Deduce the effect of dilution on the conversion of a weak base.

3.3. The study of the variation of the degree of conversion (α) of weak bases with the same initial concentration C as a function of the acidity constant K_a allows us to plot the curve represented in **Document-2**.

Document-2

Consider two solutions of two weak bases B_1 and B_2 of same concentration C. Specify whether the following statement is true or false:

The two solutions B_1 and B_2 have the same pH.

Exercise 1

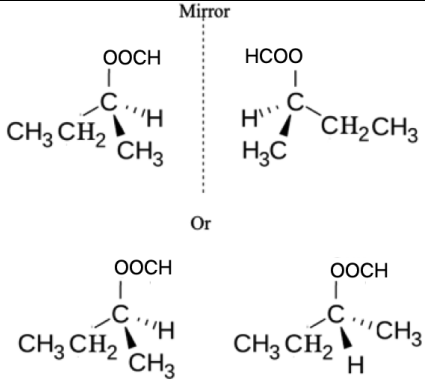| Part	Answer	Mark
1	Upon dilution, the number of moles of solute is conserved $C_o \times V_o = C_1 \times V_1$ $\frac{C_o}{C_1} = \frac{V_1}{V_o} = 100$. So, for V= 250 mL volumetric flask is used, then: $V_o = \frac{250}{100} = 2.5\ mL$ which van be taken by means of a 5 mL graduated pipet. Thus set 2 is convenient.	1
2.1.1	20 mL volumetric pipet	0.25
2.1.2	Graduated burette of 25 mL	0.25
2.2	$H_3O^+_{(aq)}$ + $HO^-_{(aq)}$ $\rightarrow$ $2H_2O_{(l)}$	0.5
2.3	At equivalence, the chemical species present in solution other than H_2O are Na^+ and $C\ell^-$. These ions are spectator ions and have no effect on pH. Thus $pH_E = 7$	0.5
2.4.	At equivalence: n (HO^-) present in 20 mL of (S1) = n (H_3O^+) added to reach equivalence $\qquad C_b \times V_b = C_a \times V_{aE}$ Then, $C = \frac{7.5 \times 10^{-2} \times 21.2}{20} = 0.0795$ mol.L^{-1}	1
2.5.	$\frac{C_0}{C_{s1}} = 100$, then $C_o = 100 \times 0.0795 = 7.95\ mol.L^{-1}$	0.5
2.6.	% NaOH $= \frac{m\ solute}{m\ solution} \times 100$. (0.25 pts) $\qquad = \frac{n \times M}{d \times V\ solution} \times 100$ Then: $\% = \frac{C_o \times M}{d} \times 100$. % of NaOH$= \frac{7.95 \times 40}{1270} \times 100 = 25\%$. (0.75 pts)	1
2.7.1	The addition of water increases the volume of the solution present in the beaker but n(HO$^-$)is conserved, thus the concentration of HO$^-$ decreases and hence the pH value decreases. So, pH$_o$ decreases.	0.75
2.7.2	For a large addition of the hydrochloric acid solution, the pH of the solution tends towards the pH of the added solution. The pH tends towards: -Log C_a = 2.12	0.75

Exercise 2   Identification and Preparation of a Food Additive

Part	Expected Answer	Mark
1.1.1.	According to test 1 (A) reacts with 2,4-DNPH then it contains **a carbonyl group** (either aldehyde or ketone).	0.75
	According to test 2 (A) reacts with Tollen's reagent to give a silver mirror then it **is an aldehyde**	0.75
1.1.2.	**(A) is an aldehyde with a saturated non-cyclic chain the nits general molecular formula is :** c- $C_nH_{2n}O$	0.5
1.2.1.	$n(A) = \frac{m}{M} = \frac{\rho \times V}{M}; M = \frac{0.8 \times 90}{1} = 72\ g.mol^{-1}$	0.75
1.2.2.	**(A) with** $C_nH_{2n}O$; 12n + 2n+ 16 = 72; n = 4 ;then, A is C_4H_8O	0.5
1.3.	**(A) is 2- methylpropanal**	0.5

	a. $CH_3 - CH - CHO$ 　　　　$\mid$ 　　　　CH_3	0.25
1.4-	Both have the same molecular formula but different structural formulas, so they are isomers.	**0.5**
2.1.	Since (A) is an aldehyde with a branched carbon chain, the (B) is a primary alcohol with a branched chain. (mild oxidation takes place without breaking down the carbon chain). Answer b	**0.75**
2.2.	$CH_3{-}CH(CH_3){-}CH_2OH + \frac{1}{2} O_2 \rightarrow H_2O + CH_3{-}CH(CH_3){-}CHO$	**0.75**
2.1-	$CH_3{-}CH(CH_3){-}COOH$ **2-methylpropanoic acid**	**0.5**

Exercises 3:   A Study of an Organic compound (E)

Part	Expected Answer	Mark
1.1.	Using the law of definite proportions: $\frac{M}{100} = \frac{16(2)}{31.37}$, M = 102 g. mol^{-1} = 12n+2n+32 ; x = 5	**0.5**
1.2.	.Since (E) is a saturated non-cyclic chain mono-functional having a molecular formula of the form $C_nH_{2n}O_2$, then it can be either a carboxylic acid or an ester	**0.5**
1.3.	Since the reaction of (E) with water (Hydrolysis) produces two organic compounds: methanoic acid and an organic compound (A) then it is an ester.	**0.5**
1.4.	**Using the law of conservation of atoms:** number of carbon atoms in (E) = number of carbon atoms in (A) + number of carbon atoms in (A), 5 = number of carbon atoms in (A) + 1 then (A) is an alcohol with 4 carbon atoms: $C_nH_{2n+2}O = C_4H_{10}O$ or using the equation: (E) + $H_2O \rightleftharpoons$ methanoic acid + (A)	**0.5**
1.5.	Since (A) is is a non-branched chain organic compound, then (E) can be either structure a or structure c.	**0.5**
1.6.1.	Since (E) is a chiral molecule then it contains an asymmetric carbon atom ; 　　　O 　　　$\parallel$ $H{-} C - O - \overset{*}{C}H - CH_2 - CH_3$ 　　　　　　$\mid$ 　　　　　CH_3	**0.5**

1.6.2.		0.75
GS 1.6.1.	Since the compound (A) is a secondary alcohol; then ester (E) is (iii) $$H-\overset{\displaystyle O}{\overset{\|}{C}}-O-\underset{\underset{\displaystyle CH_3}{\mid}}{CH}-CH_2-CH_3 \qquad \text{1-methylpropyl methanoate}$$	0.5
1.6.2.	$$H-\overset{\displaystyle O}{\overset{\|}{C}}-O-\underset{\underset{\displaystyle CH_3}{\mid}}{CH}-CH_2-CH_3 \; + H_2O \rightleftharpoons \; \mathbf{HCOOH + HO-\underset{\underset{\displaystyle CH_3}{\mid}}{CH}-CH_2-CH_3}$$	0.75
2.1.	- to increase the rate of the slow esterification reaction. - to condense the vapors back to the reaction mixture, so that not to lose any component of the reaction mixture.	0.5
2.2.	Where, $n(ester)_{actual} = \frac{m}{M} = \frac{6.12}{102} = 0.06 \; mol$ Consider the reaction complete: $R(A) = \frac{n_0}{1} = 0.1$ $R(Acid) = \frac{n_0}{1} = 0.1$, reaction mixture is stoichiometric . $$n(B)_0 = 0.1mol = n(ester)_\infty$$ $$\%yield = \frac{n \; ester_{(actual)}}{n \; ester_{(theoratical)}} \times 100 = \frac{0.06}{0.1} \times 100 = 60\%$$	0.25 0.25 0.25 0.25 0.5
2.3.	Since the reaction mixture is an equimolar mixture. So the yield remains 60%, the $$n(B)_0 = 0.2mol = n(ester)_\infty$$ $\%yield = \frac{n \; ester_{(actual)}}{n \; ester_{(theoratical)}} \times 100$, by calculation n(ester)actual $= \frac{0.2\times60}{100} = 0.12$ mol m (ester) = 12.24g answer b	0.25 0.25 0.25

Exercise 4)   **The Kinetic Study of a Slow Reaction**

Part	Expected Answer	Mark
1.1.	$$[I^-]_0 = \frac{n_{(I^-)_0}}{V_t} = \frac{C_1 \times V_1}{V_t} = \frac{0.8 \times 100}{200} = 0.4\ mol.L^{-1},$$ $$[S_2O_8^{2-}]_0 = \frac{n_{(S_2O_8^{2-})_0}}{V_t} = \frac{C_2 \times V_2}{V_t} = \frac{0.2 \times 100}{200} = 0.1\ mol.L^{-1}$$	0.5 0.5
1.2.	At $t_{1/2}$; $n\,(I^-)_{t_{1/2}} = n(I^-)_0 - n(I^-)_{reacted\ at\ t_{1/2}}$ $$\frac{n(I^-)_{reacted\ at\ t_{1/2}}}{2} = \frac{n(I_2)_{formed\ at\ t_{1/2}}}{1} = \frac{n(I_2)_\infty\,/2}{1}$$ then, at $t_{1/2}$: $n(I^-)_{reacted\ at\ t_{1/2}} = n(I_2)_\infty$ $n\,(I^-)_{t_{1/2}} = n(I^-)_0 - n(I_2)_\infty$, dividing by the volume V of the solution $$[\mathbf{I}^-]_{\mathbf{t_{1/2}}} = [\mathbf{I}^-]_\mathbf{o} - [\mathbf{I_2}]_\infty$$	0.75
2.1.		1
2.2.	Since the reaction between iodide ions and peroxydisulfate is a **complete** reaction, and since the concentration of iodide ions decreases with time to **reaches a constant value different than zero**, then iodide ions are in excess.	0.25 0.5
2.3.	$S_2O_8^{2-}$ *is the limiting reactant; then,* $n(S_2O_8^{2-})_0 = n(I_2)_\infty = 0.2 \times 100 \times 10^{-3}$ $$= 2 \times 10^{-2} mol ,$$ $[I^-]_\infty = \frac{n_{(I^-)_\infty}}{V_t} = \frac{2 \times 10^{-2}}{200 \times 10^{-3}} = 0.1\ mol.L^{-1}$; or $S_2O_8^{2-}$ *is the limiting reactant; then,* $n(S_2O_8^{2-})_0 = n(I_2)_\infty$; $[S_2O_8^{2-}]_0 \times V = [I^-]_\infty \times V$ (present in the same total volume); $$[S_2O_8^{2-}]_0 = [I^-]_\infty = 0.1\ mol.L^{-1}$$	0.25 0.5
2.4.	Using the relation: $[\mathbf{I}^-]_{\mathbf{t_{1/2}}} = [\mathbf{I}^-]_\mathbf{o} - [\mathbf{I_2}]_\infty$; $[\mathbf{I}^-]_{\mathbf{t_{1/2}}} = \mathbf{0.4 - 0.1 = 0.3}\ mol.L^{-1}$,	0.5
2.5	Half life time is the time needed for half the initial concentration of the limiting reactant to be consumed or half the maximum concentration of the product. using the curve ; t1/2 = 9.5 min	0.75
3.	The catalyst acts as a kinetic factor, which increases the rate of formation of iodine the reaction (the rate of the formation of iodine in presence of a catalyst is faster than that in absence of a catalyst), **but the presence of the catalyst doesn't affect the maximum concentration of iodine, $[I_2]_\infty$, where the curve reaches a limit $[I_2]_\infty = 100 \times 10^{-3} mol.L^{-1}$**, and at **each instant t : $[I_2]\ in\ g(t) > [I_2]\ in\ f(t)$, moreover $t_{1/2}$ in g(t) must be less than 9.5 min,** this corresponds to curve b	1

Exercise 5

Part	Answer	Mark
1	% $NH_3 = \frac{m\ solute}{m\ solution} \times 100.$ $= \frac{n \times M}{d \times V\ solution} \times 100$. Then: $\% = \frac{C_o \times M}{d} \times 100.$ $C_o = \frac{\% \times d}{M \times 100} = \frac{5.25 \times 976}{17 \times 100} = 3$ mol.L^{-1}	**1**
2.1	$14 + Log C_b = 14 + Log\ 6 \times 10^{-2} = 12.77$ $10.99 < 12.77$, then pH $< 14 + Log C_b$, thus NH_3 is a weak base	**0.75**
2.2	$NH_3 + H_2O \rightleftharpoons NH_4^+ + HO^-$	**0.5**
2.3	$\qquad\quad NH_3 + H_2O \rightleftharpoons NH_4^+ + HO^-$ At t_o $\quad 6 \times 10^{-2}$ solvent $\quad 0 \qquad 0$ At $t \leftrightharpoons$ $\quad 6 \times 10^{-2} - x \qquad x \qquad x$ $K' = \frac{[NH_4^+][HO^-]}{[NH_3]},\qquad K' = \frac{x^2}{6 \times 10^{-2} - x}.$ but $x = [HO^-] = 10^{pH-14} = 9.77 \times 10^{-4}$ mol.L^{-1} then $K' = \frac{(9.77 \times 10^{-4})^2}{6 \times 10^{-2}} = 1.59 \times 10^{-5}$ but $K' = \frac{[NH_4^+][HO^-]}{[NH_3]} \times \frac{[H_3O^+]}{[H_3O^+]} = \frac{Kw}{Ka}$, $Ka = \frac{Kw}{K'} = \frac{10^{-14}}{1.59 \times 10^{-5}} = 6.28 \times 10^{-10}$ or $K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = \frac{(6 \times 10^{-2} - 10^{pH-14})(10^{-pH})}{10^{pH-14}}$; $[NH_4^+]$ is neglected compared to the concentration C_b. $K_a = \frac{(6 \times 10^{-2})(10^{-10.99})}{10^{10.99-14}} = 6.28 \times 10^{-10}$, $pK_a = 9.2$	**1** **0.25**
2.4	Dilution of a weak base solution by 100 times, the pH of the solution decreases but by a value less then 2 units, then pH = 9.95 (a)	**1**
LS 3.1	$NH_3 + H_3O^+ \rightleftharpoons NH_4^+ + H_2O$	**0.5**
3.2	$K_R = \frac{[NH_4^+]}{[NH_3].[H_3O^+]} = \frac{1}{Ka} = 10^{9.2}$ $K_R > 10^4$, then reaction is complete. $NH_3 + H_3O^+ \rightarrow NH_4^+ + H_2O$	**0.75**
3.3	For $V_a < 15$ mL and $C_a = C_b$, so the H_3O^+ is the limiting reactant and NH_3 is in excess so the pH decreases to a value less than 10.99 but remains above 7 ; then $5.4 < pH < 10.99$	**0.75**
GS 3.1	$\alpha = \frac{n(NH_3)reacted}{n\ (NH_3)\ initial}$, $nNH_3 reacted = n(OH^-)$, $\alpha = \frac{n(OH^-)}{n\ (NH_3)initial}$, in same volume, then: $\alpha = \frac{[OH^-]}{C_1}$; $[OH^-] = \frac{Kw}{H_3O^+} = \frac{10^{-14}}{10^{-pH}} = 10^{pH-14}$ $\alpha = \frac{10^{pH-14}}{C}$	**0.75**
3.2.1.	For $C_b = 6 \times 10^{-2}$ mol.L^{-1} and pH = 10.99, $\alpha = 0.016$ For $C_b' = 6 \times 10^{-4}$ mol.L^{-1} and pH = 9.95, $\alpha' = 0.149$	**0.75**
3.2.2	$C_b' < C_b$ and $\alpha' > \alpha$, then: when the solution of NH_3 is diluted, the value of α will increases. (dilution favors the reaction of ammonia with water).	
3.3	Using the curve, as the value of K_a increases the value of α decreases, but α and pH are related by the relation $\alpha = \frac{[OH^-]}{C} = \frac{10^{pH-14}}{C}$, and starting from the same initial concentration so pH varies and the two solution B_1 and B_2 have different pH.	**0.5**