الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2018
-الموضوع-

NS28E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
ⵜⴰⴳⵍⴷⵉⵜ ⵏ ⵍⵎⵖⵔⵉⴱ
المركز الوطني للتقويم والامتحانات والتوجيه

3	مدة الإنجاز	الفيزياء والكيمياء	المادة
7	المعامل	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	الشعبة أو المسلك

The use of non-programmable scientific calculator is allowed

This exam paper consists of four exercises

Literal expressions should be given before doing numerical calculations

<u>EXERCISE I (7 points):</u>
- Electrolysis of an ionic compound: lead bromide
- Study of lactic acid reactions

<u>EXERCISE II (2,5 points):</u>
- Determining propagation speed of an ultrasonic wave in a liquid

<u>EXERCISE III (5 points):</u>
- Experimental determination of the capacitance of a capacitor
- Study of RLC series circuit

<u>EXERCISE IV (5,5 points):</u>
- Study of the vertical fall motion of a marble (small ball) in a viscous liquid
- Energetic study of an oscillating system (solid-spring)

Marking scale

EXERCISE I (7 points)

Part one and part two are independent

Part one: Electrolysis of an ionic compound: lead bromide

We carry out the electrolysis of lead bromide $Pb^{2+} + 2\,Br^{-}$ at high temperature using a power supply delivering an electric current whose intensity I is constant.

During this electrolysis, lead metal is deposited at one electrode and bromine gas is released at the other electrode.

For 1 hour ($\Delta t = 3600\,s$) of this process the mass m=20,72g of lead is formed.

Given:

- The two redox pairs involved in the reaction are $Pb^{2+} / Pb_{(s)}$ and $Br_{2(g)}/Br^{-}$;
- Faraday constant: $F = 9{,}65.10^{4}\ C.mol^{-1}$;
- Molar volume of gases: $V_m = 70{,}5\,L.mol^{-1}$ for this experiment;
- Molar mass of lead: $M\,(Pb) = 207{,}2\,g.mol^{-1}$.

0,25 **1.** What is the name of the electrode (anode or cathode) at which bromine is released?

0,75 **2.** Write the half-equation of the reaction occurring at each electrode, and the overall equation.

0,5 **3.** Determine the value of I flowing through the circuit during the time Δt.

0,5 **4.** Calculate the volume V of bromine gas released during Δt from this experiment.

Part two: Study of lactic acid reactions

2-hydroxypropanoic acid commonly called lactic acid is an organic acid involved in many biochemical reactions. It is found in milk, its derivatives, many fruits and vegetables. It can be used as an additive agent of foods and in preparation of pharmaceutical skin products.

This part aims at studying the reaction between lactic acid and sodium hydroxide, and that between lactic acid and an alcohol.

1. Study of the reaction between lactic acid and sodium hydroxide

Given:

- All measurements are made at 25°C;
- The structural formula of the lactic acid is $CH_3 - CH(OH) - COOH$ which denoted AH and its conjugate base A^{-};
- The acid dissociation constant of the acid-base pair $AH_{(aq)} / A^{-}_{(aq)}$ is $K_A = 10^{-3,9}$;
- pH ranges of some acid-base indicators:

Acid-base indicator	Helianthine	Bromothymol blue	Cresol red
pH range	3 – 4,4	6 – 7,6	7,2 – 8,8

A volume $V_A = 15\,mL$ of an aqueous solution (S_A) of the lactic acid AH of molar concentration C_A is titrated with an aqueous solution (S_B) of sodium hydroxide of molar concentration $C_B = 3.10^{-2}\,mol.L^{-1}$ by pH measurements.

The following curve represents the variation of pH of the mixture as a function of the volume V_B of the solution (S_B) added over this titration.

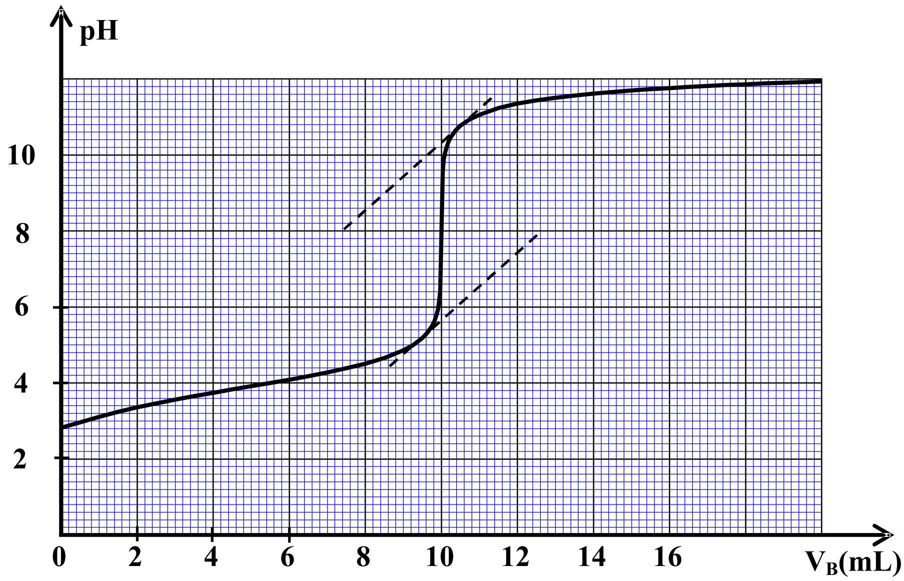
0,5 **1.1.** Write the equation of the chemical reaction occurred during this titration.

0,5 **1.2.** Determine the coordinates V_{BE} and pH_E of the equivalence point.

0,5 **1.3.** Calculate the molar concentration C_A of the solution (S_A).

0,5 **1.4.** Which acid-base indicator is the suitable from the suggested for this titration? Justify your answer.

0,75 **1.5.** Calculate the ratio $\frac{[A^-]}{[AH]}$ when the volume $V_B = 10\,mL$ of solution (S_B) is added then deduce which chemical specie AH or A^- is predominant.



2. Study of the reaction between lactic acid and methanol

An amount $n_0 = 10^{-3}\,mol$ of lactic acid $CH_3 - CH(OH) - COOH$ is mixed in a flask with an amount $n_0 = 10^{-3}\,mol$ of pure methanol $CH_3 - OH$. The reaction mixture is heated under reflux for a period of time. At the end of the reaction, we obtain an amount $n_E = 6.10^{-4}\,mol$ of an ester E.

0,5 **2.1.** State two characteristics of the occurred reaction.

0,5 **2.2.** Suggest two kinetic factors to speed up the esterification reaction.

0,5 **2.3.** Using the structural formulae, write the equation of the reaction occurring between lactic acid and methanol.

0,75 **2.4.** Calculate the yield **r** at the final state.

EXERCISE II (2,5 points)

Determining propagation speed of an ultrasonic wave in a liquid

Mechanical waves travel only in material mediums. They propagate faster in material medium which has high relative density.

To determine the approximate value V_p of the propagation speed of an ultrasonic wave travelling in petroleum (liquid) we carry out the following experiment:

Two transmitters E_1 and E_2 are connected to a low frequency generator (LFG), they are fixed on a side of a tank containing petroleum. At the same instant of time $t = 0$, E_1 and E_2 send two ultrasonic waves, one travels in the air and the second travels in the petroleum. On the other side of the tank, we fixed two receivers R_1 and R_2.

The receiver R_1 captures the ultrasonic wave which travels in the air, and the receiver R_2 captures the wave that travels in the petroleum.

We visualize on the oscilloscope screen the two received signals by R_1 and R_2. (see figure2)

Given:

-The two waves travel same distance $L = 1,84\,m$;

-The propagation speed of ultrasonic waves in the air is $V_{air} = 340\,m.s^{-1}$;

-The time-base (horizontal sensitivity) on the oscilloscope is set at $2ms/div$.

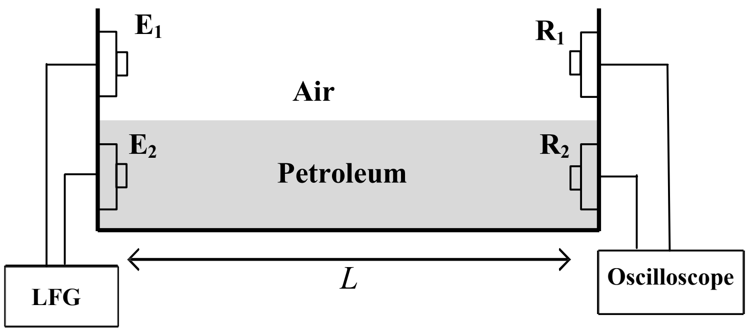


Figure 1

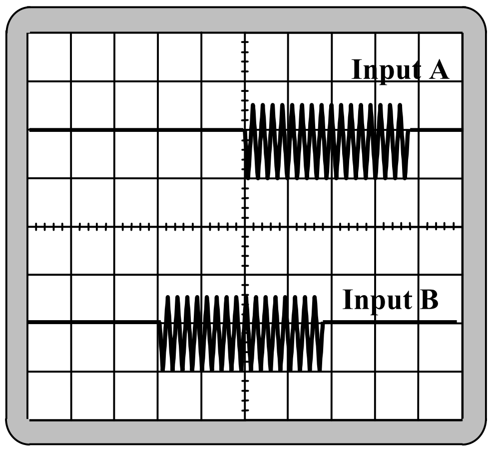


Figure 2

0,5 **1.** Is the ultrasonic wave longitudinal or transverse? Justify your answer.

0,5 **2.** Using figure 2, determine the time delay τ between the two received waves.

0,75 **3.** Show that : $\tau = L.(\frac{1}{V_{air}} - \frac{1}{V_p})$

0,75 **4.** Calculate the approximate value of V_p.

EXERCISE III (5 points)

A teacher devoted with his students a practical work session to determine capacitance of a capacitor by two different experimental methods and to study a RLC series circuit.

I-Experimental determination of the capacitance of a capacitor

1- By using an ideal generator of current

The teacher instructed a team of students to perform the experimental set-up of the circuit shown in figure 1 which consists of:

- an ideal generator of electric current I_0;
- a resistor of resistance R ;
- two capacitors (c_1) and (c_2) in parallel, the first one of capacitance $C_1 = 7,5\,\mu F$ and the second one of unknown capacitance C_2;
- a switch K.

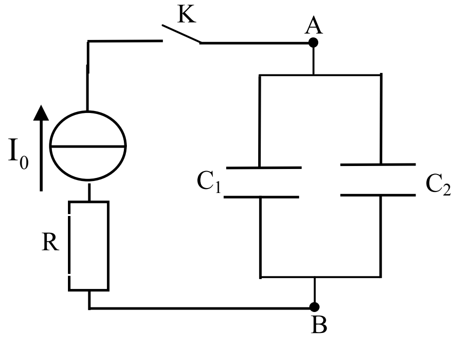


Figure 1

A student switches on the circuit at t=0. Using a datalogger, the obtained curve represents the variation of the total charge q of the equivalent capacitor of (c_1) and (c_2) as a function of the voltage u_{AB} (see figure 2)

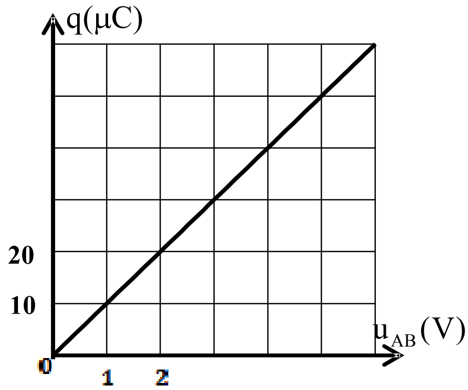


Figure 2

0,5 **1.1-** What is the interest from connecting capacitors in parallel?

0,75 **1.2-** By investigating the curve in figure 2, determine the value of the total capacitance C_{eq} of the two capacitors.

0,5 **1.3-** Deduce the value of C_2.

2- By studying the RC dipole response to a step voltage

A second team of students performs the experimental set-up of the circuit shown in figure 3, it consists of:

-an ideal power supply of electromotive force E;
-a resistor of resistance $R = 1600\Omega$;
-the previous capacitor of capacitance C_2;
-a double switch K.

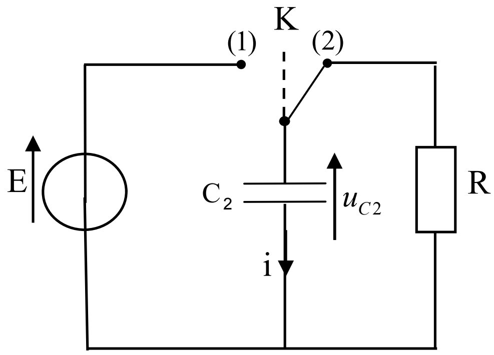


Figure3

When the capacitor is fully charged, a student puts the switch K in position (2) at t=0.
Using a datalogger, the obtained curve represents the variation of the voltage $u_{C_2}(t)$ between terminals of the capacitor (figure 4, next page).

0,5 **2.1-** Find out the differential equation for the voltage $u_{C_2}(t)$ during discharging the capacitor.

0,5 **2.2-** The solution of this differential equation is $u_{C_2}(t) = E.e^{-\frac{t}{\tau}}$. Find out the expression of the time-constant τ in terms of C_2 and R.

0,5 **2.3-** Determine again the value of C_2.

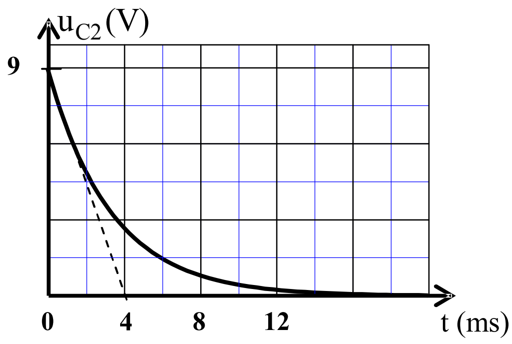


Figure 4

II-Study of RLC series circuit

A student performs the experimental set-up of the circuit shown in figure 5, it consists of :

-a capacitor fully charged of capacitance $C = 2,5\,\mu F$;

-an inductor of inductance L and internal resistance r;

-a switch K.

After switching on the circuit, and by using a datalogger, underdamped oscillations of the capacitor's charge q(t) are displayed.

0,25 **1.** Explain why the obtained oscillations are underdamped.

2. The underdamped oscillations are maintained by setting up in series in the previous circuit a generator delivering a voltage which is proportional to current intensity where $u_G(t) = k.i(t)$.

0,5 **2.1.** Find out the differential equation for q(t) the charge of the capacitor.

0,25 **2.2.** When k = 5 (S.I) the oscillations become sinusoidal, determine the value of r.

0,75 **2.3.** Using the curve in figure 6, determine the value of L.

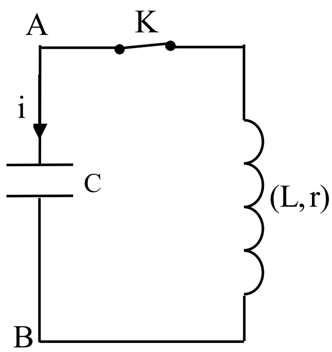


Figure 5

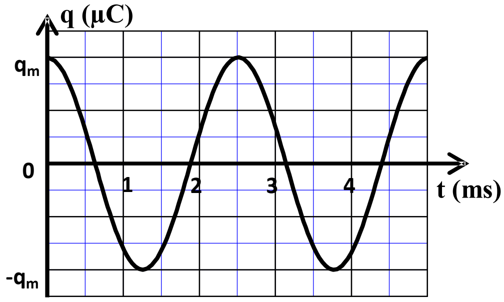


Figure 6

EXERCISE IV (5,5 points)

Part one and part two are independent

Part one: Study of the vertical fall motion of a marble in a viscous liquid

To determine some characteristics of the fall motion of a marble (small ball) in liquid, we perform the following experiment:

We fill in a graduated tube with a transparent viscous liquid of density ρ. Inside this tube, we release without initial speed a homogenous marble of mass $m = 2.10^{-2}\,kg$ and volume V, its centre of inertia is G.

We study the motion of the centre of inertia G of the marble in a frame of reference $(O,\vec{j})$ assumed Galilean.

We locate the position of G at an instant of time t by the ordinate y on the downward y-axis $\overrightarrow{Oy}$ (figure 1).

At the origin of time t=0, the position of G coincides with the origin of $\overrightarrow{Oy}$. We consider that the upthrust force $\vec{F}_a$ (Archimedes' force) is not negligible compared with the other forces acting on the marble.

We model the viscous frictional force by $\vec{f}=-k.\vec{v}_G$ where $\vec{v}_G$ is the speed of G at an instant t and k is a positive constant.

The magnitude of the upthrust force is equal to the weight of the displaced liquid $F_A=\rho.V.g$ where g is the strength of the gravitational field.

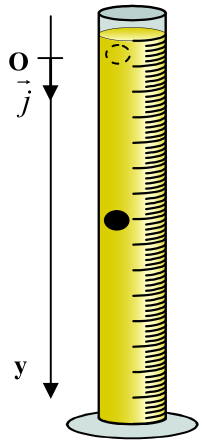


Figure 1

To determine the instantaneous speed of G, we use a camera and appropriate software. The treatment of the experimental data permits to obtain the curve shown in figure 2 which represents the variation of the speed v_G as a function of time t.

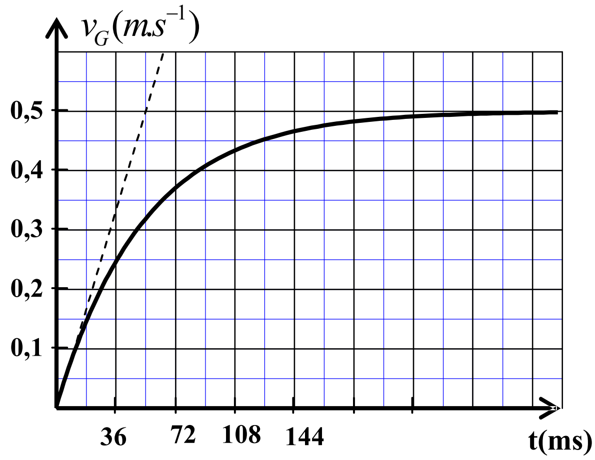


Figure 2

1 **1.** By applying Newton second law, show that the differential equation of the motion of the centre of inertia G of the marble, is written as:

$$\frac{dv_G}{dt}+\frac{1}{\tau}v_G=A$$ then determine the expression of τ the characteristic time in terms of k and m and that of A in terms of g, m, ρ and V.

0,5 **2.** Determine graphically the value of the terminal speed $v_{G_{lim}}$ and τ.

1 **3.** Find the values of k and A.

1 **4.** The differential equation of the motion of G is written as: $\frac{dv_G}{dt}=9,26-18,52.v_G$.

Calculate the approximate values of a_3 and v_4 by using Euler's method and data of the following table:

t (s)	v_G (m.s^{-1})	a_G (m.s^{-2})
⋮	⋮	⋮
0,015	0,126	a_3
0,020	v_4	6,28
0,025	0,192	5,70

Part two : Energetic study of an oscillating system (solid-spring)

We model a piece of a mechanical machine by an oscillating system (S) consisting of a solid (S) of centre of inertia G and of mass m attached to one extremity of a horizontal spring with non-contiguous turns of spring constant $K = 35\,N.m^{-1}$ and its mass is negligible. The other extremity is attached to a fixed stand.

We displace the solid (S) by a distance X_m from its position of equilibrium then we release it without initial speed. The solid oscillates on a horizontal plane without friction.

We study the motion of the centre of inertia G in a Galilean frame of reference $(O,\vec{i})$ linked to the Earth.

At equilibrium, the position of G coincides with O the origin of the frame $(O,\vec{i})$.

We locate the position of G at one instant of time t using the displacement x (abscissa) in the frame $(O,\vec{i})$.(figure 3)

We assume that the elastic potential energy to be zero when the centre of inertia G at the position of equilibrium (x=0).

The equation of the displacement-time of G is written as $x(t) = X_m.\cos(\frac{2\pi t}{T_0} + \varphi)$.

The curve in figure 4 represents the displacement-time *x(t)*.

0,75 **1-** Determine the values of X_m , T_0 and φ .

0,5 **2-** Find the value of the elastic potenial energy E_{pe1} of the oscillating system at the instant $t_1 = 0,5\,s$.

0,75 **3-** Calculate the work $W_{AB}(\vec{F})$ of the restoring force applied by the spring on the solid (S) when its centre of inertia G moves from position A ($x_A = X_m$) to position B ($x_B = -X_m$).

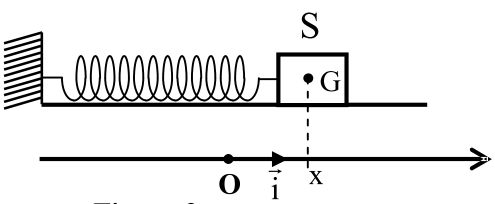


Figure 3

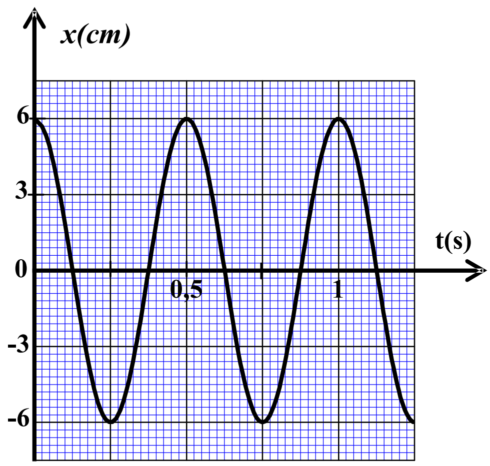


Figure 4

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وزارة التربية الوطنية
والتكوين المهني
والتعليم العالي والبحث العلمي

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المركز الوطني للتقويم والامتحانات والتوجيه

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2018
- عناصر الإجابة -

NR28E

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المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	المعامل	7

EXERCISE I (7 points)				
	Questions	**Answers**	**Marking scale**	**Question reference In the framework**
Part one	**1**	The bromine gas is released at the anode.	**0,25**	Recognize the anode electrode (oxidation) and the cathode electrode (reduction) using the flow of electric current imposed by an external voltage supply.
	2	$Pb^{2+} + 2e^- \rightleftarrows Pb_{(s)}$ $2Br^- \rightleftarrows Br_{2(g)} + 2e^-$ $Pb^{2+} + 2Br^- \rightarrow Pb_{(s)} + Br_{2(g)}$	**0,25** **0,25** **0,25**	Write the half-equation that occurred in each electrode (use double arrows) and write the overall equation of the reaction during electrolysis (use one arrow).
	3	$I = \dfrac{2.m.F}{M(Pb).\Delta t}$ -N.A : $I \simeq 5{,}36\,A$	**0,25** **0,25**	Establish the relationship between the amount of substance of chemical specie produced or consumed, the current intensity and the operating duration of electrolysis. Use this relationship to determine other quantities (quantity of charge, progress of the reaction, change of the mass, volume of a gas, etc.).
	4	- Method -N.A : $V \simeq 7{,}05L$	**0,25** **0,25**	
Part two	**1.1**	The equation of titration reaction (with one arrow)	**0,5**	Write the equation of titration reaction (use only one arrow)
	1.2	$V_{BE} = 10mL$ Consider right any value of pH_E between 7,8 and 8,2	**0,25** **0,25**	- Exploit the curve or the results of the titration. - Determine and exploit the point of equivalence.
	1.3	$C_A = \dfrac{C_B.V_{BE}}{V_A}$ $C_A = 2.10^{-2}\,mol.L^{-1}$	**0,25** **0,25**	
	1.4	Cresol red + Justification	**2x0,25**	- Justify the choice of a suitable indicator to determine the equivalence.

	1.5	- Method -Consider right any value of $\frac{[A^-]}{[AH]}$ between $7,94.10^3$ and 2.10^4 - The predominant chemical specie is A^- .	0,25 0,25 0,25	-Exploit the curve or the results of the titration. -Indicate the predominant chemical specie taking into consideration pH of aqueous solution and pK_A of pair acid/base.
	2.1	non- complete (limited) and slow transformation.	2x0,25	- Know the characteristics of esterification and hydrolysis: non-complete and slow transformations.
	2.2	Consider 2 statements of the following: -increasing the temperature; -using a catalyser; -increasing the initial concentration of a reactant.	2x0,25	-Know the effect of reactant concentration and the temperature on the volumetric rate of reaction. -Know that a catalyst is a chemical specie that increases the rate of a chemical reaction without changing the equilibrium state of the system.
	2.3	The equation of reaction using structural formulae.	0,5	Write the esterification and the hydrolysis equation.
	2.4	- Expression of the yield -N.A: $r = 60\%$	0,5 0,25	- Calculate the yield of a chemical transformation.

EXERCISE II (2,5 points)			
Questions	**Answers**	**Marking scale**	**Question reference In the framework**
1	longitudinal waves + justification	0,25x2	- Define a transverse wave and a longitudinal wave. -Exploit the relationship between time delay, distance and wave speed. -Exploit experimental documents and data in order to determine a: distance; time delay; wave speed.
2	$\tau = 4ms$	0,5	
3	Showing the relation	0,75	
4	- Method $V_p \approx 1303\, m.s^{-1}$	0,5 0,25	

EXERCISE III (5 points)			
Questions	**Answers**	**Marking scale**	**Question reference In the framework**
1.1	Increasing capacitance	**0,5**	-Know the capacitance of the equivalent capacitor in series or in parallel assemblies; and recall the interest of each one. -Determine the capacitance of a capacitor graphically or by calculation.
1.2	Method $C_{eq} = 10^{-5}\ F$	**0,5** **0,25**	
1.3	$C_2 = C_{eq} - C_1$ $C_2 = 2,5.10^{-6}\ F$	**0,25** **0,25**	
2.1	$\frac{du_{C2}}{dt} + \frac{1}{RC_2}.u_{C2} = 0$	**0,5**	-Find out the differential equation and verify its solution when the RC dipole is submitted to a step voltage. -Know and exploit the time-constant expression. -Exploit experimental documents in order to: determine the time-constant and charge duration.
2.2	$\tau = R.C_2$	**0,5**	
2.3	$C_2 = 2,5.10^{-6}\ F$	**0,5**	
1	losing or wasting energy by Joule effect	**0,25**	-Explain energetically the three regimes..
2.1	$\frac{d^2q}{dt^2} + \frac{(r-k)}{L}.\frac{dq}{dt} + \frac{1}{LC}.q = 0$	**0,5**	Find out the differential equation for the voltage between the capacitor's terminals or for its charge $q(t)$ in the RLC circuit that is maintained by using a generator delivering a voltage which is proportional to the current intensity: $u_G(t) = k.i(t)$
2.2	$r = 5\Omega$	**0,25**	Know the role of the oscillation maintenance device which compensates the energy dissipated by Joule effect in the circuit.
2.3	Method $L \approx 6.10^{-2}\ H$	**0,5** **0,25**	-Exploit experimental documents in order to: determine the values of the period and the natural period. - Know and exploit the natural period expression.

EXERCISE IV (5,5 points)

	Questions	Answers	Marking scale	Question reference In the framework
Part one	1	- Method $\tau = \frac{m}{k}$ $A = g.(1 - \frac{\rho.V}{m})$	0,5 0,25 0,25	- Know Newton's second law $\Sigma\overrightarrow{F_{ext}} = m.\frac{\Delta\overrightarrow{V_G}}{\Delta t}$ and $\Sigma\overrightarrow{F_{ext}} = m.\overrightarrow{a_G}$ and its range of validity. -Apply Newton's second law to find out the differential equation of a solid's centre of inertia motion in frictional vertical fall. - Exploit the curve $v_G = f(t)$ to determine: * the terminal speed; * the characteristic time τ ; - Know and apply the Euler's method to solve approximately differential equation.
	2	$v_{G\lim} = 0,5\,m.s^{-1}$ $\tau = 54\,ms$	0,25 0,25	
	3	$k = \frac{m}{\tau} \approx 3,7.10^{-1}\ (S.I)$ $A = \frac{v_{G\lim}}{\tau} \approx 9,26\ m.s^{-2}$	0,5 0,5	
	4	-Method $a_3 \approx 6,93\,m.s^{-2}$ method $v_4 \approx 0,161\,m.s^{-1}$	0,25 0,25 0,25 0,25	
Part two	1	$X_m = 6\,cm$ $T_0 = 0,5\,s$ $\varphi = 0$	0,25 0,25 0,25	- Know the meaning of the physical quantities involved in the expression of the parametric equation $x_G(t)$ of the oscillating system (solid-spring) and determine them using the initial conditions.
	2	$E_{pe1} = \frac{1}{2}K.X_m^2$ $E_{pe1} = 6,3.10^{-2}\,J$	0,25 0,25	- Know and exploit the expression of the elastic potential energy.
	3	Method $W_{AB}(\vec{F}) = 0$	0,5 0,25	-Determine the work of an external force exerted by a spring. - Know and exploit the expression of the elastic potential energy.