المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

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المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2019
- الموضوع -

RS30E

المادة	الفيزياء والكيمياء	مدة الانجاز	4
الشعبة أو المسلك	شعبة العلوم الرياضية : (أ) و (ب) خيار أنجليزية	المعامل	7

The use of the non-programmable scientific calculator is allowed.

This exam paper consists of four exercises; one in Chemistry and three in Physics.

Exercise 1 : Chemistry (7 points)

- Titration of an aqueous solution of methylamine
- Basic Hydrolysis of an ester

Exercise 2 : Mechanical waves (3 points)

- Propagation of a wave along a rope

Exercise 3 : Electricity (5 points)

- Response of the RC circuit to a step of voltage
- Free oscillations in RLC series circuit
- Forced oscillations in RLC series circuit

Exercise 4 : Mechanics (5 points)

- Oscillatory motion and free fall of a solid
- Motion of an artificial satellite

Exercise 1: Chemistry (7 points)

Parts I and II are independent.

The sodium hydroxide and the methylamine are chemical compounds which are used in the production of many synthetic products.

In this first part of the exercise, we propose to study the titration of an aqueous solution of methylamine and in the second part, the basic hydrolysis of an ester.

Part I : Titration of an aqueous solution of methylamine

We have an aqueous solution (S) of methylamine CH_3NH_2 of molar concentration C . We take a volume $V=10\,mL$ of the solution (S) which we titrate by an aqueous solution of the hydrochloric acid $H_3O^+_{(aq)}+Cl^-_{(aq)}$ of molar concentration $C_A=2.10^{-2}\ mol.L^{-1}$. The curve in figure 1 represents the variation of the pH of the reaction mixture in function of the volume V_A of the acid poured.

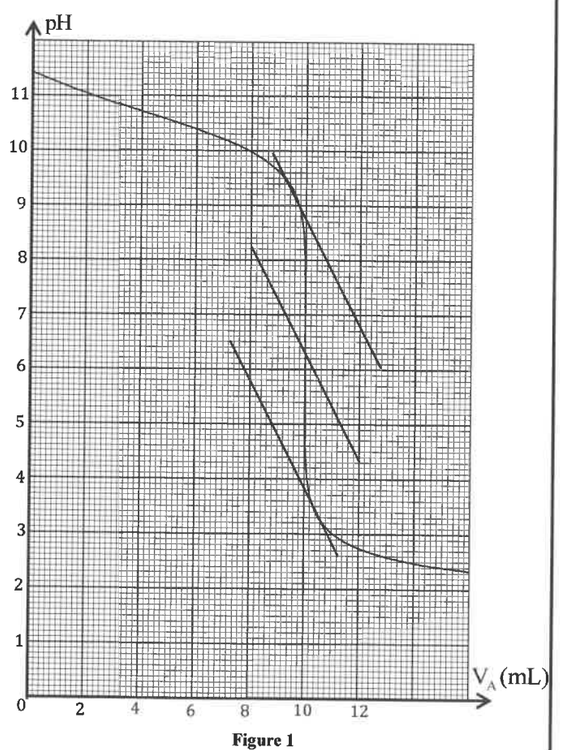


Figure 1

Given: - All measurements are performed at 25^0C ;

- The ionic product of water: $K_e=10^{-14}$;

1- Determine graphically the coordinates V_E and pH_E of the equivalence point. **(0,5pt)**

2- Determine the concentration C . **(0,5pt)**

3- Between the indicators shown in the table bellow, indicate which one is suitable for the colorimetric titration of this solution (S) . Justify your answer. **(0,5pt)**

Indicator	Range of colour
Bromcresol Green	3,8- 5,4
Bromthymol Blue	6,0- 7,6
Phenolphthalein	8,2- 10,0

4- Write the chemical equation of the titration reaction. **(0,5pt)**

5- With the help of the progress table of the chemical reaction of the titration of the solution (S) , show that for

$V_A < V_E$: $pH = pK_{A1} + \log\left(\frac{1}{y} - 1\right)$ with $y = \frac{V_A}{V_E}$ and $pK_{A1} = pK_A(CH_3NH^+_{3(aq)} / CH_3NH_{2(aq)})$.**(0,5pt)**

6- Determine the value of y to get $pH = pK_{A1}$. Deduce the value of pK_{A1}. **(0,75pt)**

7- For the solution (S) previously titrated:

7-1- Write the chemical equation of the reaction of the methylamine with water. **(0,25pt)**

7-2- Determine the final progress rate of this chemical reaction. What can we deduce? **(0,5pt)**

Part II: Basic Hydrolysis of an ester

The propylethanoate is an ester denoted E and characterized by its smell of pear. It is used in industry of perfume, aroma, paints, lubricants, etc,

1- Write the structural formula of the ester E. **(0,25pt)**

2- We perform, at the instant of date $t = 0$, two equimolar mixtures of the ester E and an aqueous solution of sodium hydroxide. Each mixture is constituted of a volume V_E of solution of the ester E of molar concentration $C_1 = 10^{-2}$ mol.L^{-1} and a volume $V_B = V_E$ of an aqueous solution of sodium hydroxide of the same concentration. In the determined experimental conditions in each reaction mixture occurs a chemical reaction modeled by the equation:

$$E_{(\ell)} + HO^-_{(aq)} \longrightarrow CH_3COO^-_{(aq)} + A_{(\ell)} .$$

For one of the mixtures, the experiment is performed at the temperature θ_1. For the other, it is performed at the temperature θ_2 with $\theta_2 > \theta_1$.

The curves $\mathscr{C}$ and $\mathscr{C}$' in figure 2 represent the evolution of the concentration $\left[CH_3COO^-_{(aq)}\right]$ during the time at the temperature θ_1 and the temperature θ_2.

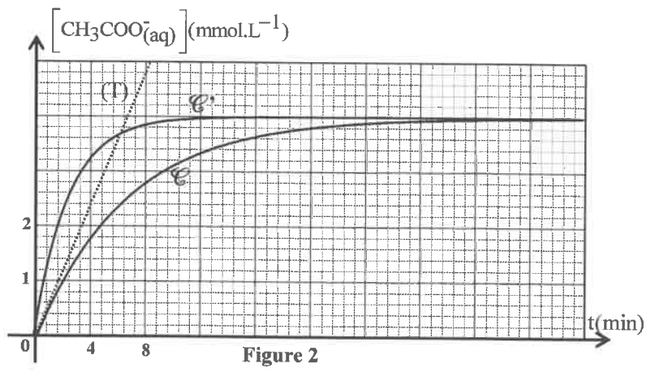


Figure 2

2-1- Determine $t_{1/2}$ the half-life of a chemical reaction of the basic hydrolysis of the ester corresponding to the curve $\mathscr{C}$. **(0,5 pt)**

2-2- By comparing the half-life of a chemical reaction, deduce the curve corresponding to the temperature θ_2. **(0,5pt)**

2-3- Determine in mmol.L^{-1}.min^{-1} unit the volumetric rate of the reaction at the instant $t = 0$ corresponding to curve $\mathscr{C}$. (T) represents the tangent of the curve at the instant $t = 0$. **(0,5pt)**

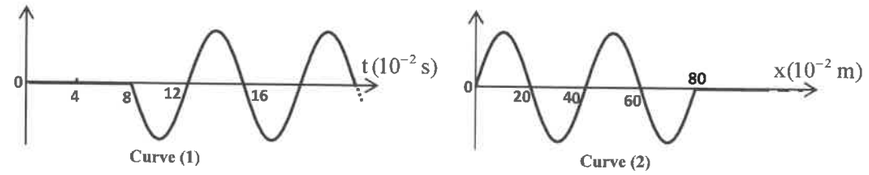
2-4- Determine, at the temperature θ_1, the reaction quotient Q_r at the instant $t = t_{1/2}$. **(0,75pt)**

2-5- Determine the yield of this chemical reaction. **(0,5pt)**

Exercise 2 : Propagation of a wave along a rope (3 points)

A vibrating blade in sinusoidal motion of frequency N, attached to the end S of a very long and horizontally taut elastic rope SA, generates along of this one a progressive periodic undamped wave of velocity v. An appropriate device, placed in A, prevents any reflection of the waves. The motion of S starts at the instant $t = 0$.

The curves (1) and (2) of the figure bellow represent the elongation on a point M of the rope, located at distance d from S and the appearance of the rope at an instant t_1.



1- Identify, justifying, the curve which represents the appearance of the rope at the instant t_1. **(0,25 pt)**

2- Give the number of the true statements from the following: **(0,5 pt)**

a- The diffraction phenomenon never happens for a mechanical wave.

b- The periodic sinusoidal progressive waves are characterized by a temporal periodicity and spatial periodicity. .

c-The wave which propagates along of the rope is a longitudinal wave.

d- The propagation velocity of a mechanical wave does not depend on the wave amplitude.

3- By exploiting the previous curves, determine:

3-1- The wavelength λ, the period T and the speed v of the wave. **(0,75 pt)**

3-2-The time delay τ of the point M with respect to the source S of the wave and deduce the distance d.**(0,5 pt)**

4- We give the relationship between the wave speed v, the tension F of the rope and its linear mass density μ (divide the mass by the length): $v = \sqrt{\frac{F}{\mu}}$.

4-1- Using the dimensional analysis, check the homogeneity of the previous relationship. **(0,25 pt)**

4-2- Is the rope a dispersive medium? Justify. **(0,25 pt)**

4-3- We double the tension F $(F' = 2F)$ of the rope without changing the frequency of the vibrating blade. Determine in this case the wavelength λ' of the wave? **(0,5 pt)**

Exercise 3: Electricity (5 points)

We take $\pi^2 = 10$.

I- Study of the RC dipole and the free oscillations in the RLC circuit

We perform the mounting shown in figure 1 which consists of:
- An ideal generator of voltage of e.m.f E;
- Two resistors of resistances $R_1 = 1{,}5.10^5\,\Omega$ and $R_2 = 32\,\Omega$;
- Two capacitors (C_1) and (C_2) respectively of capacitances C_1 and $C_2 = 4\,\mu F$, without initial charge;
- A double switch K;
- An inductor (b) of inductance $L = 0{,}2\,H$ and of resistance $r = 10\,\Omega$.

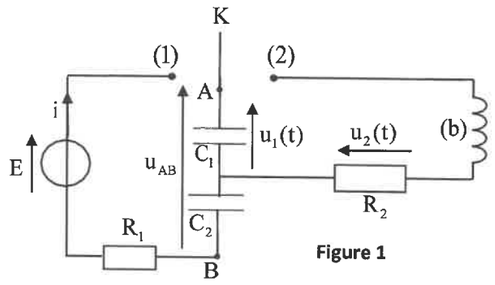


Figure 1

1 – Study of RC dipole

We put the switch (K) on position (1) at an instant $t = 0$. An adequate computing system allows us to draw the variation of the voltage $u_{AB}(t)$ (figure 2). Line (T) represents the tangent of the curve at t=0 .
We denote by C_e the equivalent capacitance, in series, of (C_1) and (C_2).

1-1- Find out the differential equation of the voltage $u_{AB}(t)$. **(0,5pt)**

1-2- The solution of the differential equation is: $u_{AB}(t) = U_0(1 - e^{\alpha t})$.

Find the expressions of U_0 and α in terms of the parameters of the circuit. **(0,5pt)**

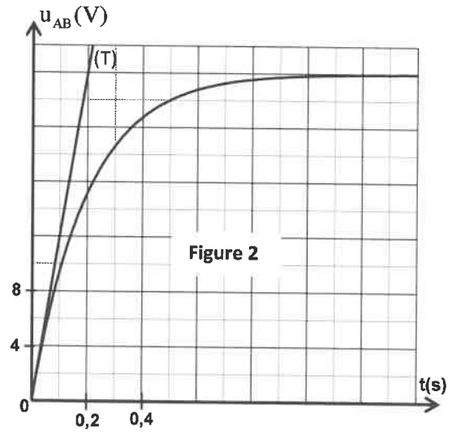


Figure 2

1-3- By Using the curve in figure 2:

1-3-1- Determine the value of E . **(0,25pt)**

1-3-2- Find out the value of the capacitance C_1. **(0,25pt)**

1-4- Establish, in the international system of units, the numerical expression of the charge $q_1(t)$ of the capacitor (C_1). **(0,5pt)**

2- Study of the free oscillations in the RLC circuit

When we reach the steady state, we switch the switch K to position (2) at an instant assumed as a new origin of dates $(t = 0)$. An adequate computing system allows us to draw the curve of voltage $u_2(t)$ between the terminals of the resistor of the resistance R_2 (figure 3).

2-1- Establish the differential equation of the voltage $u_2(t)$. **(0,5pt)**

2-2- Assuming that the value of the pseudo-period is the same as that of the natural period. Check that $C_1 = 2\,\mu F$. **(0,5pt)**

2-3- To maintain the damped oscillation obtained, we introduce in series into the circuit a generator which delivers a voltage $u_g = k.i(t)$ with u_g is expressed in volt (V) and $i(t)$ is expressed in ampere (A).
Find out the value of k. **(0,5pt)**

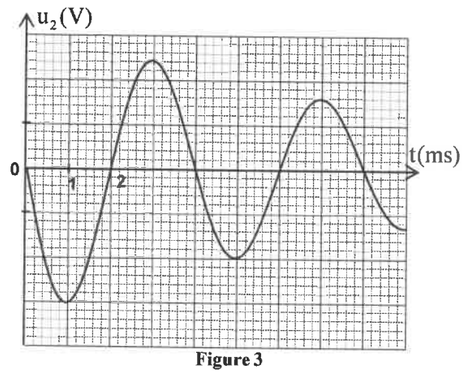


Figure 3

II- Study of forced oscillations in RLC series circuit.

We perform a series electric circuit which consists of the elements bellow:
- A low frequency generator (GBF) which delivers a sinusoidal alternating voltage u(t) of variable frequency N and a constant maximum voltage.
- A capacitor of capacitance C;
- The previously inductor (b) used;
- A resistor of resistance $R = 40\,\Omega$.

We adjust the frequency of the (GBF) on the value N_0 then we visualise, with the help of an adequate computing system, both voltage $u_R(t)$ between the terminals of the resistor and voltage u(t) between the terminals of the generator. We obtain the oscillograph represented in Figure4.

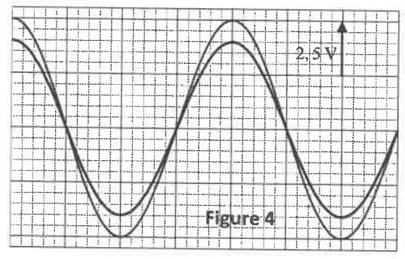


Figure 4

1- Schematize the experimental mounting and the connections of the computing system (the connections of the computing system to the circuit are identical to that of the oscilloscope). **(0,5pt)**
2- Check the value of the resistance r of the inductor. **(0,5pt)**
3- Calculate the average electrical power P_0 dissipated by Joule effect in the circuit. **(0,5pt)**

Exercise 4 : Mechanics (5 points)

Parts I and II are independent

Part I : Motion of an oscillator and a free fall of a solid

We model a toy by a mechanical system which consists of:
- Spring $(\mathscr{R})$ of non-contiguous turns, a negligible mass, a spring constant $K = 50\,N.kg^{-1}$,
- A solid (S) of mass $m = 50\,g$ and center of inertia G.

Given: - The gravitational field strength: $g = 10\,m.s^{-2}$; $\alpha = 30^0$.
We study the motion of the solid (S) in two situations:

Situation A: Oscillatory motion of the solid (S)

We attach to one of the ends of the spring ($\mathscr{R}$) the solid (S) and we fix the other end of the spring to a fixed stand.

The solid (S) can slide without frictions on the inclined plan at an angle α to the horizontal plan.

We study the motion of the center of inertia G of the solid in a frame of reference $R(O,\vec{i},\vec{j})$ linked to the earth assumed Galilean. We locate the position of G at an instant t by the displacement x on the x-axis $(O,\vec{i})$.

At the rest position, G coincides with the origin O of the frame of reference (figure 1).

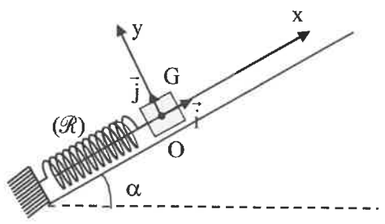


Figure 1

1- Show that the expression of the extension $\Delta\ell_0$ of the spring at the rest position is written as $\Delta\ell_0 = -\dfrac{mg\sin\alpha}{K}$. **(0,25pt)**

2- We displace (S) from its rest position by the distance $d = 2\,cm$ in the positive direction and we release it at an instant (t=0) without initial velocity.

We choose as reference level of the gravitational potential energy $(E_{pp} = 0)$ the horizontal plane passes through G at the rest position and as reference level the elastic potential energy $(E_{pe} = 0)$ when the spring is not deformed.

2-1- Show that the expression of the total potential energy of the oscillator at an instant t is written as :

$E_p = E_{pp} + E_{pe} = \dfrac{1}{2}K\left(x^2 + (\Delta\ell_0)^2\right)$. **(0,5pt)**

2-2- By using an energetic study, establish the differential equation of the displacement $x(t)$. **(0,5pt)**

2-3-Knowing that the solution of the differential equation is written as: $x(t) = X_m.\cos\left(\dfrac{2\pi}{T_0}t + \varphi\right)$ with T_0 is the natural period of the oscillator, find out V_0 the value of the velocity of G, at its passage through the rest position in the positive direction. **(0,5pt)**

Situation B: Motion of free fall of the solid (S)

We release the solid (S) from the spring ($\mathscr{R}$). We compress enough the spring and we put on its free ends the solid (S) ; then we release the spring. At an instant given, the solid (S) leaves the spring and reaches point O_1 with velocity $\vec{V}_{01}$ at an angle α to the horizontal plane and of value $V_{01} = 2\,m.s^{-1}$ (figure 2) and falls in free fall.

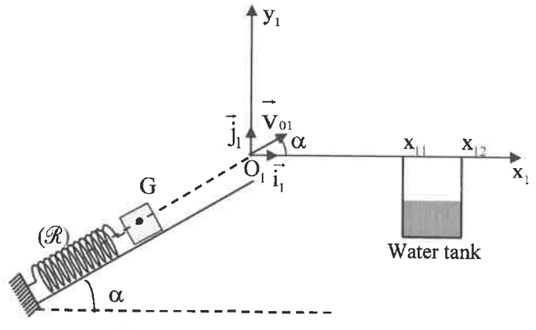


Figure 2

We study the free fall motion of the centre of inertia G in the frame of reference $(O_1,\vec{i}_1,\vec{j}_1)$ linked to the earth assumed Galilean.

We choose the instant of the passage of G through O_1 as origin of dates ($t = 0$).

1- Applying Newton's second law; find out the numerical expression of the parametric equations of $x_1(t)$ and $y_1(t)$ of the motion of G. **(0,5pt)**

2- Deduce the numerical expression of the equation of the path of G. **(0,5pt)**

3- Does the solid (S) fall into the water tank of width $L = x_{12} - x_{11}$ with $x_{11} = 30\,cm$ and $x_{12} = 40\,cm$ (figure 2)? Justify your answer. (We neglect the dimensions of (S)). **(0,5pt)**

Part II: Motion of an artificial satellite

The purpose of this part is to determine the mass of the earth with two methods.

Given:

- The acceleration of gravity on the surface of the earth: $g_0 = 9,8\ m.s^{-2}$;
- Constant of universal gravitation: $G = 6,67.10^{-11}\ SI$.
- We take $\pi^2 = 10$.

We assume that the earth is spherical of center O, radius $R_T = 6400\,km$, mass M_T and having a spherically mass distribution.

We assume that the artificial satellite obeys only to the Universal Gravitation force applied by the earth.

1/1-1- By identifying weight and Universal Gravitation force at ground level, find out the expression of the gravitational field intensity g_0 at the Earth's surface in terms of M_T , R_T and G . **(0,5pt)**

1-2- Calculate M_T. **(0,25pt)**

2- In the geocentric frame of reference assumed Galilean, an artificial satellite (S) describes a circular orbit around the earth of period of revolution $T = 98\,min$. The artificial satellite is located at an altitude $h = 647\,km$ above the surface of the Earth.

2-1- Establish the relationship translating the Kepler's third law relative of the center of inertia of (S).**(0,5pt)**

2-2- Deduce M_T the masse of the earth and compare it with that found in question 1-2. **(0,5pt)**