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المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2018
-الموضوع-

RS27E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والإمتحانات والتوجيه

المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية : مسلك علوم الحياة والأرض – خيار أنجليزية	المعامل	5

- **The use of the non-programmable scientific calculator is allowed.**
- **Give the literal expressions before every numerical application.**

This exam paper consists of four exercises: one in chemistry and three in physics.

- **Chemistry: Ethanoic acid and its utilizations** **(7 points)**
- **Physics:** **(13 points)**
  - **Exercise 1: Uranium-Thorium dating method** **(3 points)**
  - **Exercise 2: Studying the response of a dipole** **(5 points)**
  - **Exercise 3: Studying the motion of a cyclist in a circuit** **(5 points)**

scale	Subject

Chemistry (7 points): Ethanoic acid and its utilizations

The Ethanoic acid of formula CH_3COOH represents the principal constitutent of commercial vinegar after water. It is used as a reactive in a few organic syntheses, like the one that leads to the Ethyl ethanoate. The degree of acidity of vinegar is given by degree (°).

This exercise consists of 3 different parts, and aims at:

- ***Studying an aqueous solution of ethanoic acid;***
- ***Determining of the degree of acidity of commercial vinegar;***
- ***Studying the synthesis of Ethyl ethanoate from the ethanoic acid.***

Data:

- The degree of acidity of vinegar is equal to the mass, in grams, of the pure acid that contains $100\ mL$ of vinegar.
- $pK_A(CH_3COOH(aq)/CH_3COO^-(aq)) = 4,8$ at $25°C$; $M(CH_3COOH) = 60\ g.mol^{-1}$

<u>Part 1</u>: Studying an aqueous solution of ethanoic acid

The measurement of pH of an aqueous solution of ethanoic acid, at $25°C$, gives $pH = 3,0$.

0,5 **1.** Write the chemical equation of the transformation between the ethanoic acid and water.

0,5 **2.** Determine the predominant substance of the pair $(CH_3COOH(aq)/CH_3COO^-(aq))$ in this solution. Justify

1 **3.** Determine the value of the reaction quotient $Q_{r,eq}$ at the equilibrium of the chemical system.

0,5 **4.** Will the value of $Q_{r,eq}$ be modified if we dilute the solution of the ethanoic acid? Justify.

<u>Part 2</u>: The determination of the degree of acidity of commercial vinegar

The tag of a bottle of commercial vinegar indicates $6°$. The molar concentration of ethanoic acid in this vinegar is C_0.

We intend to make a pH-titration of this vinegar to determine its degree of acidity. For this, we prepare an aqueous solution (S_1) with 10 times dilution of the commercial vinegar, and we take a volume $V_A = 25\ mL$ of the diluted solution (S_1) of molar concentration C_A $\left(C_A = \frac{C_0}{10}\right)$ which we titrate with an aqueous solution (S_2) of Sodium Hydroxide $Na^+_{(aq)} + HO^-_{(aq)}$ of molar concentration $C_B = 2,5.10^{-1} mol.L^{-1}$.

At the equivalence, the volume added of the solution (S_2) is $V_{B,E} = 10\ mL$.

0,5 **1.** Write the equation of reaction of titration (supposed total).

0,75 **2.** Calculate the value of C_A. And deduce the value C_0.

0,75 **3.** Verify the value of the degree of acidity of vinegar indicated in the tag of the bottle.

<u>Part 3</u>: Studying the synthesis of Ethyl ethanoate from the ethanoic acid.

In a round-bottom flask, we pour an equimolar mixture of $n_1 = 0,3\ mol$ of ethanoic acid and $n_2 = 0,3\ mol$ of ethanol, and some drops of concentrated sulfuric acid. At the equilibrium of the chemical system, the amount of matter of Ester formed is: $n_f(ester) = 0,2\ mol$.

The synthesis of the Ethyl ethanoate is described in the equation of reaction:

$$CH_3COOH_{(\ell)} + C_2H_5OH_{(\ell)} \rightleftharpoons CH_3COOC_2H_{5(\ell)} + H_2O_{(\ell)}$$

0,75 **1.** Identify the organic functional groups of the organic molecules present in the equation of synthesis.

0,25 **2.** Give the characteristics of this reaction.

0,5 **3.** Determine the value of the yield of this synthesis.

0,5 **4.** Determine the value of the equilibrium constant K associated to the chemical equation of esterification.

0,5 **5**. To synthetize the Ethyl ethanoate in a fast and total transformation, it is possible to replace the ethanoic acid by one of its derivatives.
Give the displayed formula (semi-developed) of this derivative.

Physics (13 points)

Exercise 1 (3 points): Uranium-Thorium dating method

The marine sediments contain the thorium $^{230}_{90}Th$ ***and the uranium*** $^{234}_{92}U$ ***with different percentages according to their ages. The thorium*** $^{230}_{90}Th$ ***present in these sediments comes from the spontaneous disintegration of the uranium*** $^{234}_{92}U$ ***during time.***

The aim of this exercise is to study the disintegration of uranium $^{234}_{92}U$ **.**

Data:

- The energies of mass of the nuclei and the nucleus of uranium 234:

	92 protons	142 neutrons	Nucleus $^{234}_{92}U$
Energy of mass (MeV)	86321,9	133418,5	218009,1

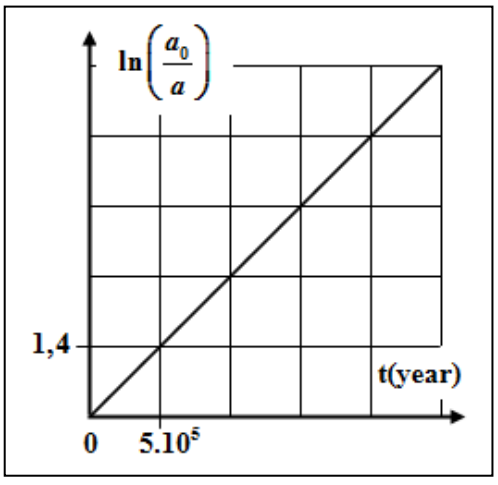
0,5 **1.** Give the composition of the nucleus of thorium $^{230}_{90}Th$.

0,75 **2.** Write the equation of disintegration of $^{234}_{92}U$. Identify the type of this disintegration.

0,75 **3.** Copy on your answer sheet the number of the question, and write the letter corresponding to the right option (A,B,C or D).
The binding energy of uranium $^{234}_{92}U$ is:

A	$1,65.10^3\,MeV$	**B**	$1,73.10^3\,MeV$	**C**	$1,85.10^3\,MeV$	**D**	$1,98.10^3\,MeV$

4. We consider a sample of a marine sediment which was formed at an instant $t_0 = 0$. This sample contains N_0 nucleus of uranium (without thorium nucleus).
We name a_0 the radioactivity of the sample at an instant $t_0 = 0$ and a the radioactivity of the sample at an instant t.
The curve on the right represents the variations of $ln\left(\frac{a_0}{a}\right)$ in function of time.



0,5 **4.1.** Determine, graphically , the value of the radioactivity constant λ of uranium 234 with the unit $(year^{-1})$.

0,5 **4.2.** The study of the sample at an instant t_1 (the age of the sample) shows that $\frac{a_0}{a} = \sqrt{2}$.
Determine the value of t_1 the age of the sample with the unit (year).

Exercise 2 (5 points): Studying the response of a dipole

Electric circuits or electronic circuits contain capacitors and inductors which have different behaviors according to their use.

The aim of this exercise is to:

- ***Study of the response of RC dipole to a step voltage.***
- ***Study of free electric oscillations and the energy exchange in RLC series.***

We realize the electric assembly representing in figure (1), which is constituted from the following elements:

- Ideal voltage generator of electromotor force E;
- A capacitor of capacitance C, initially not charged;
- An inductor $(L, r = 0)$;
- Two ohmic conductors of resistances respectively $R_1 = 6\ k\Omega$ and R_2;
- Switch K.

1. Response of RC dipole to a step voltage

At an instant $t_0 = 0$, we place the switch K on the position (1). Figure (2) represents the variation of the voltage $u_C(t)$ between the capacitor terminals.

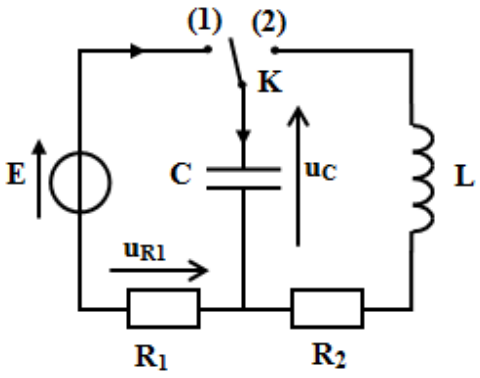


Figure (1)

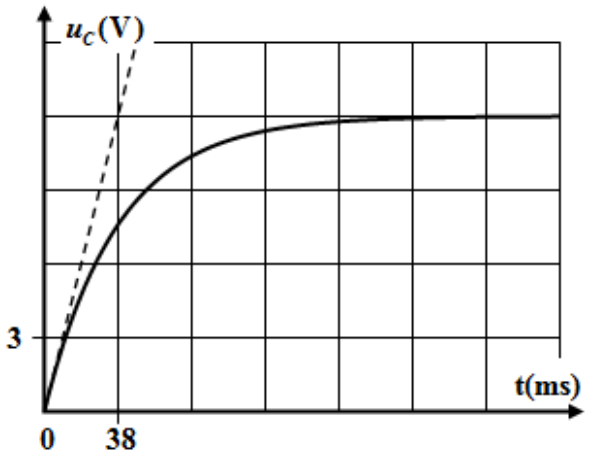


Figure (2)

0,75 **1.1.** Prove that the differential equation verified by u_C is written as: $\frac{du_C}{dt} + \frac{1}{\tau}.u_C = \frac{E}{\tau}$ where τ is a positive constant. Give the expression of τ.

0,75 **1.2.** Determine, graphically, the values of E and τ.

0,25 **1.3.** Verify that $C \simeq 6,3\ \mu F$.

2. Study of free electric oscillations and the energy exchange in RLC series

When the permanent state is reached, we permute the switch K to the position (2) at an instant $t_0 = 0$.

The curve in figure (3) represents the variation of the voltage $u_C(t)$ between the capacitor terminals.

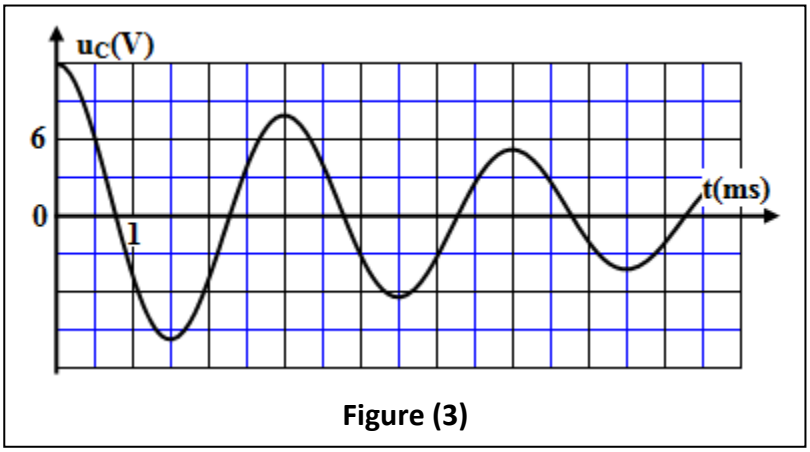


Figure (3)

0,5 **2.1.** Justify the nature of the electric oscillations in the circuit.

0,5 **2.2.** Determine the value of the charge Q_0 of the capacitor at the instant $t_0 = 0$.

0,25 **2.3.** Determine, graphically, the value of the pseudo-period T of the oscillations.

0,5 **2.4.** We consider that the pseudo-period T is equal to the proper period of the (LC) oscillator. Determine the value of the inductance L of the inductor (we take $\pi^2 = 10$).

2.5. The curves in figure (4) represent the variations in function of time the electric energy stored in the capacitor $\mathscr{E}_e$, the magnetic energy stored in the inductor $\mathscr{E}_m$ and the total energy $\mathscr{E}$ of the circuit, where $\mathscr{E} = \mathscr{E}_e + \mathscr{E}_m$.

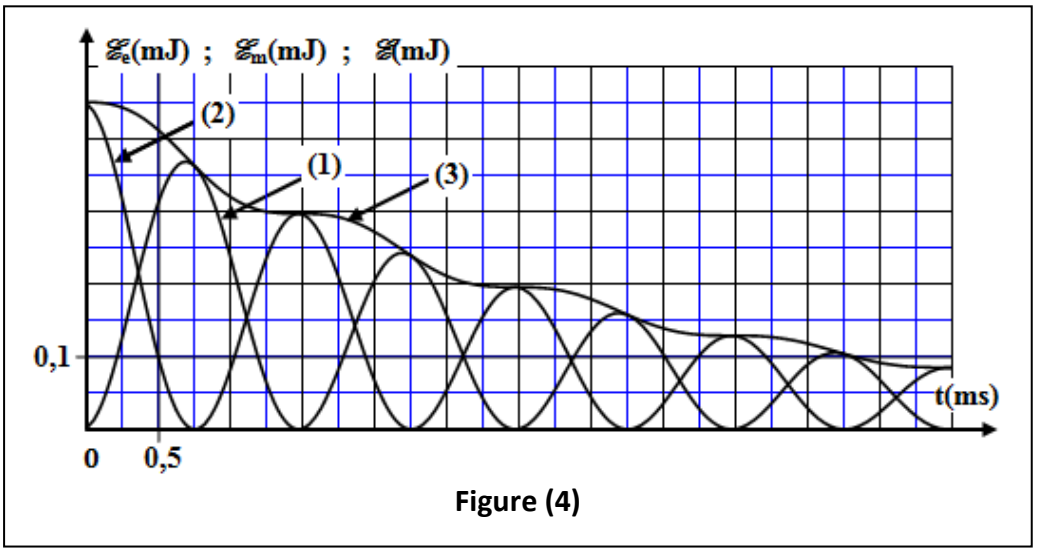


Figure (4)

0,5 **2.5.1.** Identify, by justification, the curve corresponding to the magnetic energy $\mathscr{E}_m$.

1 **2.5.2.** Determine, between the instants $t_0 = 0$ and $t_1 = 3\ ms$, the variation $\Delta\mathscr{E}$ of the total energy.

Exercise 3 (5points): Studying the motion of a cyclist in a circuit

Bicycle race in closed circuits has became a popular sport. So many competitions are organized every year in closed circuits that contain obstacles.
This exercise aims to studying the motion of the center of inertia of a system {Cyclist - Bicycle} in a circuit in the Atlas area (figure 1).

During its participation in a race in a circuit (represented in figure (1)), a cyclist travels a part of the circuit constituted of a rectilinear horizontal section AB, a curvilinear section BC opened to a trench of length L and a horizontal section DE (figure 2).



Figure (1)

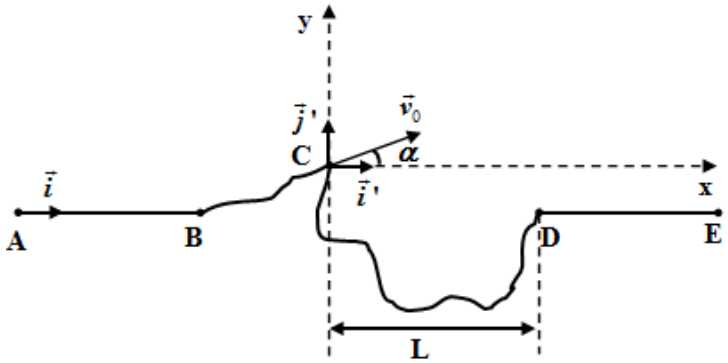


Figure (2)

The motion in the section AB is with frictions modeled by a frictional force $\vec{f}$ constant of opposite sense with velocity. We take m the mass of the system {Cyclist - Bicycle}.
We notice that G is the center of inertia of the studied system.

1. Motion of the cyclist in the section AB

The cyclist exerts an effort, between A and B, modeled by a horizontal force $\vec{F}$ supposed constant in the same sense of the motion of G.

The cyclist starts off without initial velocity from position A. To study the motion of G, we choose the frame of reference $(A,\vec{i})$ linked to the Earth and supposed Galilean. We choose at $t_0 = 0$, $x_G = x_A = 0$.

Data:

$m = 70\ kg$; $g = 10\ m.s^{-2}$; $F = 180\ N$; $f = 80\ N$; $AB = 60\ m$

1 **1.1.** Applying Newton's second law, prove that the expression of the acceleration of motion of G is written as: $a = \dfrac{F - f}{m}$.

0,5 **1.2.** Determine, by justification, the nature of the motion of G.

0,5 **1.3.** Calculate the value of the t_B the instant when G passes by B.

0,5 **1.4.** Determine the value of the speed v_B of G when it passes by B.

0,75 **1.5.** Determine the magnitude of $\vec{R}$, the force exerted by the plane on the system during its motion in section AB.

2. Motion of the cyclist during the jump

The cyclist leaves the section BC in C with a velocity $\vec{v}_0$ which makes an angle α with the horizontal plane (see figure (2)- page 5/6).

During the jump, the system {Cyclist – Bicycle} is submitted to its weight only. We study the motion of G, in an orthonormal frame of reference $(C,\vec{i}',\vec{j}')$ linked to the Earth and supposed Galilean. We choose the instant when G passes by C like a new origin of time $t_0 = 0$.

The parametric equations of motion of G during the free-fall are written as:

$$x_G(t) = (v_0.\cos\alpha).t \quad ; \quad y_G(t) = -\frac{1}{2}g.t^2 + (v_0.\sin\alpha).t$$

During its motion, G achieves the summit of the trajectory at the instant $t_S = 0{,}174\ s$ and then the system falls on the ground at the instant $t_P = 1\ s$.

Data: $\alpha = 10°$; $L = 8\ m$; $g = 10\ m.s^{-2}$

0,5 **2.1.** Prove that $v_0 = 10\ m.s^{-1}$.

0,5 **2.2.** Does the cyclist exceed the trench? Justify.

0,75 **2.3.** Determine the coordinates of the vector velocity $\vec{v}_P$ of G at the instant t_P .