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الامتحان الوطني الموحد للبكالوريا
المسالك الدولية
الدورة الاستدراكية 2022
– الموضوع –

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المملكة المغربية
وزارة التربية الوطنية والتعليم الأولي والرياضة
المركز الوطني للتقويم والامتحانات

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

- **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 (7 points)	• **Study of some reactions using methanoic acid**	**7 points**
Physics (13 points)	**Exercise 1 : Waves propagation**	**3,5 points**
	Exercise 2 : Behaviour of a capacitor in an electric circuit	**5,5 points**
	Exercise 3 : Motion of a solid in an inclined plan	**4 points**

scale	Subject

Chemistry (7 points)

The nature of chemical systems depends on the substances involved. Monitoring the evolution of these systems can be done by different methods; physical or chemical, which leads to measurements and determination of quantities characteristic of these systems and the transformations to which they are subjected.
This exercise aims to study some systems involving methanoic acid.

1. Study of solution of methanoic acid

We consider an aqueous solution (S_1) of methanoic acid $HCOOH$ of molar concentration $C_1 = 5.10^{-3} mol.L^{-1}$. The measure of conductivity of this solution, at $25°C$, gives $\sigma_1 = 33\, mS.m^{-1}$.

Data:

- Ionic molar conductivities:

$\lambda_1 = \lambda(H_3O^+) = 35,0\ mS.m^2.mol^{-1}$; $\lambda_2 = \lambda(HCOO^-) = 5,5\ mS.m^2.mol^{-1}$

- The effect of the ions $HO^-_{(aq)}$ in the conductivity of the solution is supposed negligeable.
- The conductivity σ of a solution is written in terms of the effective molar concentrations of the ions X_i and the ionic molar conductivities λ_i: $\sigma = \sum \lambda_i [X_i]$.

0,5 **1.1.** Write the chemical equation modelling the reaction between methanoic acid and water.

0,75 **1.2.** Show that $\left[H_3O^+_{(aq)}\right] = 8,15.10^{-4} mol.L^{-1}$.

0,75 **1.3.** Calculate the final rate of reaction τ_1. Conclude.

0,75 **1.4.** Show that the value of the quotient of reaction at equilibrium state of the chemical system is $Q_{r1,eq} = 1,59.10^{-4}$.

0,5 **1.5.** We dilute at $25°C$ the solution (S_1), to obtain an aqueous solution (S_2) of molar concentration C_2.
Give, by justification, the value of quotient of reaction $Q_{r2,eq}$ of chemical system at equilibrium.

2. Exploitation of evolution criteria

We consider the chemical system obtained by mixing the next amounts of matter:
$n_1 = 1,5.10^{-2} mol$ of nitrous acid HNO_2, $n_2 = 3.10^{-2} mol$ of sodium methanoat $Na^+_{(aq)} + HCOO^-_{(aq)}$,
$n_3 = 3.10^{-2} mol$ of sodium nitrite $Na^+_{(aq)} + NO^-_{2(aq)}$ and $n_4 = 1,5.10^{-2} mol$ of methanoic acid $HCOOH$.
Let V the total volume of the reactional mixture.
The equation of reaction between nitrous acid HNO_2 and methanoat $HCOO^-_{(aq)}$ ions is:

$$HNO_{2(aq)} + HCOO^-_{(aq)} \underset{(2)}{\overset{(1)}{\rightleftharpoons}} NO^-_{2(aq)} + HCOOH_{(aq)}$$

Data:

$pK_{A1} = pK_A(HNO_{2(aq)} / NO^-_{2(aq)}) = 3,2$; $pK_{A2} = pK_A(HCOOH_{(aq)} / HCOO^-_{(aq)}) = 3,8$.

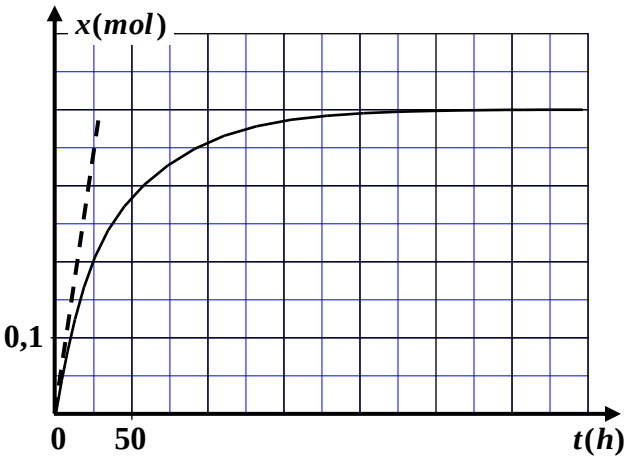
0,5 **2.1.** Determine the value of quotient of reaction $Q_{r,i}$ at initial state of the chemical system.

1 **2.2.** Prove that the equilibrium constant K associated to the previous equation of reaction is: $K = 10^{(pK_{A2} - pK_{A1})}$. Calculate the value of K.

0,5 **2.3.** Indicate, with justification, in which direction the chemical system evolves spontaneously from its initial state.

3. Temporal monitoring of a chemical reaction

A mixture initially containing methanoic acid and an alcohol is prepared. The monitoring of the reaction made it possible to plot the curve opposite representing the advancement x of the reaction as a function of time.



The total volume of the mixture is $V = 88\,mL$.

3.1. Determine graphically:

0,25 **a.** The value of the final advancement x_f of the reaction.

0,5 **b.** The value of the half-life of reaction $t_{1/2}$.

0,5 **c.** The value of the volumetric rate of reaction at the instant $t_0 = 0$ in unit $(mol.L^{-1}.h^{-1})$.

0,5 **3.2.** Qualitatively interpret the variation in the volumetric rate of reaction.

Physics (13 points)

Exercise 1 (3,5 points): propagation of waves

Study of propagation of mechanical waves and light waves permit to determine certain characteristics of waves and properties of media of propagation.

This exercise aims to study the propagation of a sound wave in air and study the dispersion of light.

1. Determination of velocity of a sound wave

A loud-speaker connected to a (GBF) emits a sound signal of frequency N. This signal is picked by a microphone located along the axis (Ox). This microphone is connected to an oscilloscope (figure 1).

Figure (2) gives the graphs of two signals picked by the microphone for two successive positions x_1 and x_2.

Signal (a) correspond to $x_1 = 20\ cm$. Signal (b) correspond to $x_2 = 36,7\,cm$, and appears for the first time in phase with graph (a).

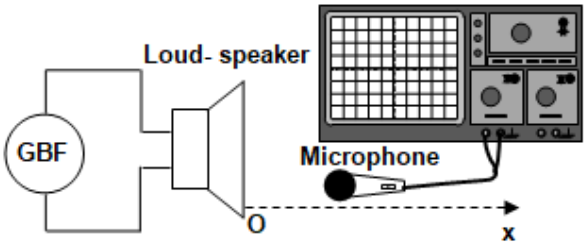


Figure 1

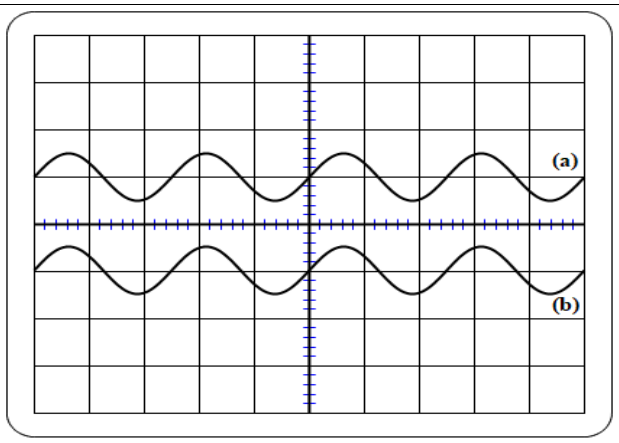


Figure 2

Data: horizontal sensitivity: $0,2\,ms.div^{-1}$

0,5 **1.1.** Determine the value of frequency N.

0,5 **1.2.** Determine the value of wavelength λ of the sound wave.

0,5 **1.3.** Determine the value of velocity v of this wave.

2. Identification of a dispersive medium

Table below gives the wavelengths in vacuum of two monochromatic radiations (Violet and blue), and the refraction indexes corresponding to every wavelength for three media of propagation: air, crown glass and flint glass.

Colour of the radiation	Violet	Blue
Wavelength in vacuum	$\lambda_{0v} = 486{,}1\ nm$	$\lambda_{0b} = 589\ nm$
Refraction index of air	$n_a = 1$	$n_a = 1$
Refraction index of crown glass	$n_c = 1{,}522$	$n_c = 1{,}517$
Refraction index of flint glass	$n_f = 1{,}682$	$n_f = 1{,}666$

Data: $c = 3.10^8\, m.s^{-1}$

0,5 **2.1.** Determine the value of the frequency of blue radiation.

0,5 **2.2.** Establish the relation between the index n of a medium, wavelength λ, frequency ν of a radiation and velocity c of light in vacuum.

0,5 **2.3.** Among the three media, indicate by justification, the ones that are dispersive.

0,5 **2.4.** Determine the value of wavelength λ_b of the blue radiation in flint glass.

Exercise 2 (5,5 points): behaviour of a capacitor in an electric circuit

Association of electric components like coil, capacitor and ohmic conductor leads to different electric dipoles like RC and RLC which, placed in circuits, engender phenomena as charge and discharge of a capacitor and free electric oscillations …

This exercise aims to:

- **Study the response of a dipole RC to a step-voltage;**
- **Energetic study of an oscillating circuit LC.**

We study the behaviour of a capacitor in two different situations (a) and (b) using the assembly in figure (1) which contains:

- An ideal generator of electromotive force E;
- A capacitor of capacity C;
- Two ohmic conductors of resistances R and R';
- A coil of inductance L and neglected resistance;
- A switch K of two positions.

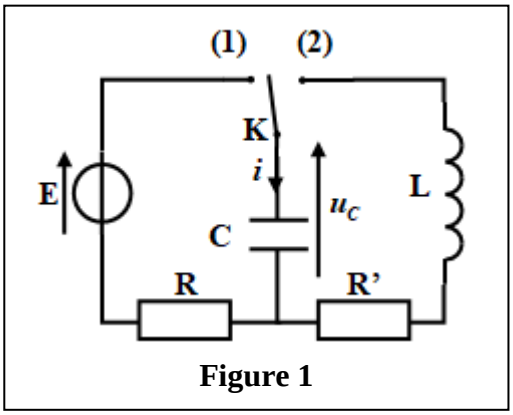


Figure 1

Data: $R = 100\ \Omega$

Part 1: Study of the behaviour of a capacitor in situation (a)

At instant $t_0 = 0$, we place the switch K in position (1).

0,25 **1.** What is the interest of this assembly is this case?

0,75 **2.** Using additivity law of voltages, prove that the current intensity $i(t)$ passing in the circuit is linked to the charge $q(t)$ of the capacitor by the relation: $i = -\frac{1}{R.C}.q + \frac{E}{R}$.

3. Using an adequate acquisition system, we obtain the graph of figure (2) which represents the evolution of i in terms of q.

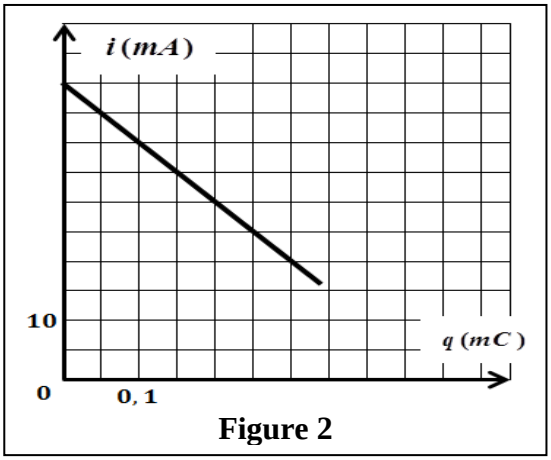


Figure 2

By exploiting the graph, determine the values of:

0,5 **a.** Maximal intensity of electric current I_0;

0,5 **b.** Electromotive force E ;

0,5 **c.** Time constant of the circuit τ ;

0,5 **d.** The maximal charge Q_{max} of the capacitor at the end of its charge.

Part 2: Study of the behaviour of the capacitor in situation (b)

Once the capacitor is totally charged under the voltage $u_{C0} = E$ in the situation (a), we switch K to the position (2) at an instant $t_0 = 0$.

Figure (3) gives the variations of voltage $u_C(t)$ between the terminals of the capacitor.

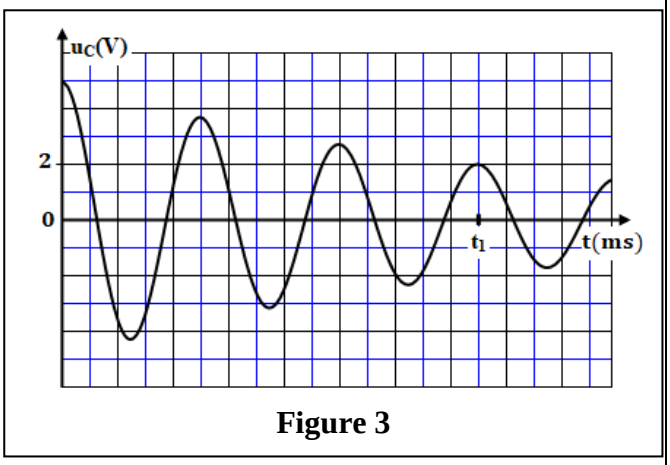


Figure 3

0,25 **1.** Give the name of the regime of oscillations shown in the graph of figure (3).

0,5 **2.** Explain, from energetic point of view, the regime of oscillations in the circuit.

3. We note respectively $\mathscr{E}_0$ and $\mathscr{E}_1$ the total energies of the circuit at instants $t_0 = 0$ and $t_1 = 188\,ms$.

The variation of the total energy of the circuit between t_0 and t_1 is $\Delta\mathscr{E} = -10,5.10^{-4}\,J$.

0,75 **3.1.** We note u_{C1} the voltage in the terminals of the capacitor at the instant t_1.

Prove that the capacity of the capacitor can be expressed by the relation $C = \dfrac{2.\Delta\mathscr{E}}{u_{C_1}^2 - E^2}$. Calculate the value of C.

0,25 **3.2.** The capacitor utilised can be replaced by two identical capacitors each one have a capacity C_0 in parallel. Determine the value of C_0.

0,75 **3.3.** We suppose that the pseudo-period T is equal to the period T_0 of the free non dumped oscillations.

Determine the value of L (we take $\pi^2 = 10$).

Exercise 3 (4 points): Motion of a solid in an inclined plan

Motions of mechanical systems are generally governed by Newton's laws.
The state of motion of these systems depends on the mechanical actions and initial conditions.
This exercise aims to determine of certain magnitudes during the motion of a solid in an inclined plan.

We consider a solid (S) of mass m, susceptible to slide according to the line of the steepest slope of an inclined plan of an angle α with the horizontal.

The solid (S) starts with initial velocity $\vec{v}_0$, at an instant $t_0 = 0$ from the position O. During the motion along the path OA, the solid is submitted to frictions modelling by a constant force $\vec{f}$ of the same direction as velocity vector and opposite sense.

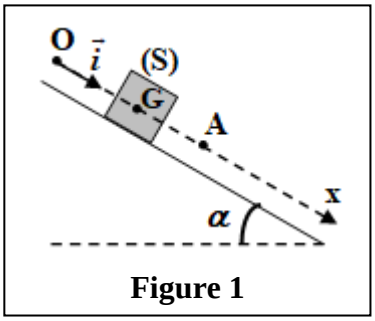


Figure 1

We study the motion of the centre of inertia G of solid (S) in the frame of reference $(O,\vec{i})$ linked to Earth supposed Galilean (figure 1).

The abscissa of G at $t_0 = 0$ is $x_G = x_0 = 0$.

Data: $m = 500\,g$; $g = 10\,m.s^{-2}$; $\alpha = 20°$

0,5 **1.** By applying Newton's second law, prove that the differential equation verified by x_G is :

$$\frac{d^2x_G}{dt^2} = g.\sin\alpha - \frac{f}{m}$$

2. Figure (2) gives the evolution of velocity $v(t)$ of G.

0,75 **2.1.** Determine, graphically, the values of the acceleration a_G and initial velocity v_0 of motion of G.

0,5 **2.2.** Write the parametric equation $x(t)$ of motion of G.

0,5 **2.3.** Calculate the intensity of the force $\vec{f}$.

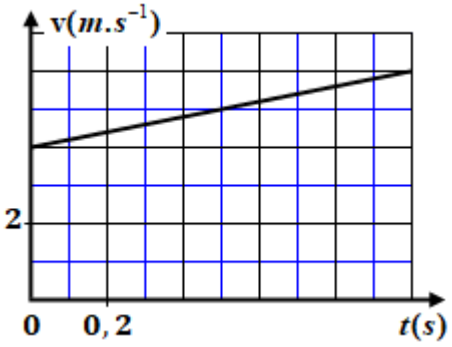


Figure 2

3. After that the solid (S) passes from point A with a velocity $v_A = 6\,m.s^{-1}$, it is no longer submitted to friction force $\vec{f}$, it passes through a position B after having traversed the distance AB.

0,25 **3.1.** Determine the nature of motion of G after passing through A.

3.2. We choose A as new origin of abscissa and the instant when G passes by A as new origin of dates.

The centre of inertia G of the solid (S) passes through position B with a velocity $\vec{v}_B$ at the instant $t = 1\,s$.

Determine:

0,5 **a.** The value of the distance AB.

0,5 **b.** The value of the velocity v_B.

0,5 **3.3.** Determine the intensity of the force $\vec{R}$ exerted by the inclined plan on the solid (S).