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# الامتحان الوطني الموحد للبكالوريا
## المسالك الدولية- خيار أنجليزية
الدورة العادية 2017
- الموضوع -

NS 30E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

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| المادة | الفيزياء والكيمياء | مدة الإنجاز | 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.

## Chemistry (7 points)

- Study of an aqueous solution of the methanoic acid
- Synthesis of an ester

## Physics (13 points)

✓ **Waves (2,75 points)**

- Diffraction of a monochromatic light
- Energy levels of an atom

✓ **Electricity (5 points)**

- Charging and discharging of a capacitor
- Receiving an electromagnetic wave

✓ **Mechanics (5,25 points)**

- Study of the falling motion of two objects
- Study of the motion of a physical pendulum

Marking scale

## Chemistry (7 points)

**Part one and part two are independent**

**Part one: Study of an aqueous solution of the methanoic acid**

The methanoic acid $HCOOH$ is a natural substance produced by ants and bees. It can be produced in the chemistry lab to be used in the industry of textile, leather, dyes and pesticides…
Under normal conditions, the physical state of the methanoic acid is liquid.
This part aims at:

- Checking the mass percentage p of the methanoic acid in a commercial aqueous solution of this acid.
- Determining the value of $pK_A$ of the pair $HCOOH_{(aq)} / HCOO^-_{(aq)}$ using two different methods.

A container label of a commercial solution $(S_0)$ of the methanoic acid mentions the following information:

- Molar mass : $M(HCOOH) = 46\,g.mol^{-1}$ .
- Relative density : $d = 1,15$ .
- Mass percentage : $p = 80\%$ .

**Given :**

- $p = 80\%$ means that 100 g of the commercial solution contains 80 g of pure acid;
- Density of the water: $\rho_w = 1 kg.L^{-1}$ ;
- Molar ionic conductivities: $\lambda_{H_3O^+} = 3,50.10^{-2}\,S.m^2.mol^{-1}$ , $\lambda_{HCOO^-} = 5,46.10^{-3}\,S.m^2.mol^{-1}$ ;
- The expression of the conductivity $\sigma$ of a solution is : $\sigma = \sum_i \lambda_{x_i}.[X_i]$ where $[X_i]$ is the effective molar concentration of each ion $X_i$ present in the solution and $\lambda_{x_i}$ its molar ionic conductivity;
- The impact of the hydroxide ions $HO^-$ on the conductivity of the solution studied is negligible.

We prepare an aqueous solution (S) of the methanoic acid of molar concentration $C$ and of volume $V_S = 1L$ by adding $V_0 = 2\,mL$ of the commercial solution $(S_0)$ of molar concentration $C_0$ to the distilled water.

**1-Determination the value of $pK_A$ of the pair $HCOOH_{(aq)} / HCOO^-_{(aq)}$ by titration:**

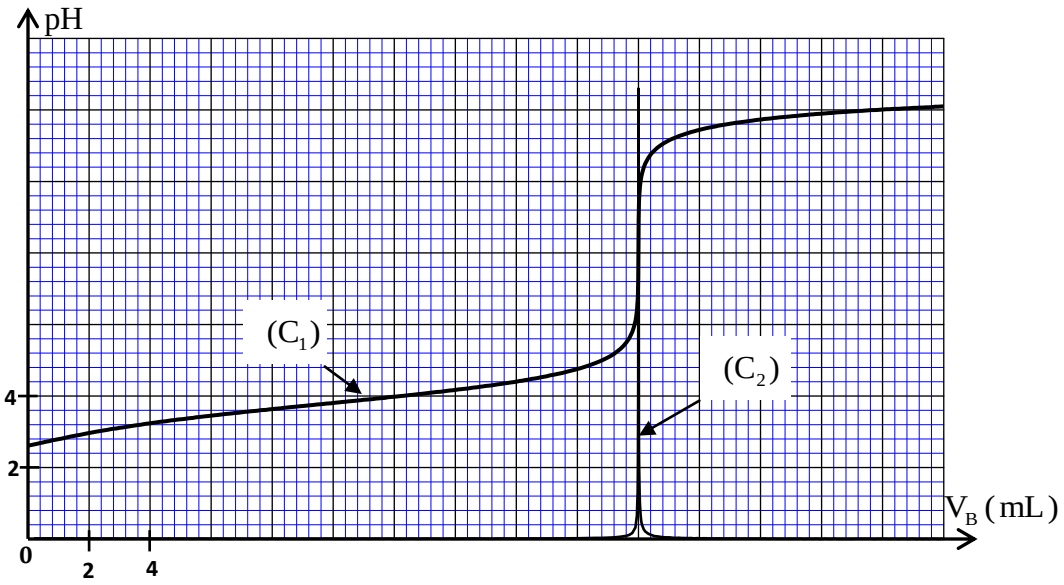
We titrate the volume $V_A = 50\,mL$ of the solution (S) by using an aqueous solution $(S_B)$ of the sodium hydroxide $Na^+_{(aq)} + HO^-_{(aq)}$ of molar concentration $C_B = 0,1 mol.L^{-1}$ by monitoring the pH of the reaction mixture in accordance with the volume $V_B$ added to the solution $(S_B)$.
In the figure on page 3/8, curve $(C_1)$ shows the variation of pH with $V_B$ ; ( $pH = f(V_B)$ ) and curve $(C_2)$ shows the variation of $\frac{dpH}{dV_B}$ with $V_B$ ; ( $\frac{dpH}{dV_B} = g(V_B)$ ).

**0,5** **1-1-**Write the chemical equation of the transformation which occurs during this titration.

**0,75** **1-2-**Determine the value of the volume $V_{BE}$ added at the equivalence point, and calculate the value of the molar concentration $C$ of the solution $(S)$.

**0,5** **1-3-** Verify that the value of p is the same as the one mentioned in the label.

**1** **1-4-** When we add a volume $V_B = 16\,mL$ of the solution $(S_B)$ and based on the progress table, determine which chemical species is predominant among $HCOOH$ and $HCOO^-$ and deduce the value of $pK_A(HCOOH_{(aq)} / HCOO^-_{(aq)})$.




**2- Determination the value of $pK_A$ for the pair $HCOOH_{(aq)} / HCOO^-_{(aq)}$ by conductiometry**

We take a volume $V_1$ of the solution (S) of molar concentration $C = 4.10^{-2}\ mol.L^{-1}$, the measurement of its conductivity gives $\sigma = 0,1 S.m^{-1}$.

**0,5** **2-1-** Write the chemical equation of the reaction between methanoic acid and water.

**0,5** **2-2-**Find out the expression of the final progress $x_f$ of the reaction in terms of $\sigma$ , $\lambda_{H_3O^+}$ , $\lambda_{HCOO^-}$ and $V_1$.

**0,5** **2-3-**Show that the final progress rate is $\tau \simeq 6,2\%$.

**0,75** **2-4-** Find out the expression of $pK_A(HCOOH_{(aq)} / HCOO^-_{(aq)})$ in terms of C and $\tau$. Calculate its value.

**Part two: Synthesis of an ester**

Esters are organic substances with special flavours. They can be used in food and medicinal industry. Esters can be extracted from some natural substances and can also be synthesised in the chemistry lab. In this part, we study the reaction between the methanoic acid and the propan-1-ol $(C_3H_7OH)$.

**Given:** Molar mass: $M(HCOOH) = 46\ g.mol^{-1}$.

A mixture (S), of $n_1 = 0,2\ mol$ the methanoic acid and of $n_2 = 0,2\ mol$ the propan-1-ol, is heated under reflux at constant temperature. We obtain an organic compound and water.

The instant at which the reaction starts is assumed as an origin of time ($t = 0$).

**0,5** **1-**Choose which one of the following statements is true:

During the esterification reaction:

**a-** The amount of substance of the ester formed decreases when we remove the water.

**b-** Half-life of a chemical reaction decreases when we use a catalyst.

**c-** The quotient of the reaction decreases.

**d-** The volumetric rate of the reaction increases during the evolution of the system.

**0,75** **2-**Using the structural formulae, write the chemical equation of the reaction present. Give the name of the organic compound formed.

**0,75** **3-**At one instant of time $t_1$, the mass of acid remaining is $m = 6,9\ g$.

Knowing that the yield of this reaction is $r = 67\%$, show that the equilibrium of this reaction has not been reached yet at this instant.

## Physics (13 points) :

# Waves (2,75 points) :Diffraction of a monochromatic light – energy levels of an atom.

The purpose of this exercise is to study some properties of the red light emitted by a helium-neon laser (He-Ne). The wavelength of this light in the air is $\lambda = 633\,nm$.

**Given** : - Speed of light in the air : $c = 3.10^{8}\ m.s^{-1}$ ;

- Planck constant : $h = 6,63.10^{-34}\ J.s$ ;
- $1eV = 1,6022.10^{-19}\ J$ ;
- For the small angles, we have $\tan\theta \approx \theta$ where $\theta$ is expressed in radian.

### 1-Diffraction of a monochromatic light emitted by helium-neon laser (He-Ne)

We use the monochromatic red light, emitted by a helium-neon laser, to determine the width **a** of a gap aperture. To reach this objective, we carry out the experiment as it is shown in figure 1.
We illuminate the slit of the width **a** by a laser beam and we observe a series of spot lights fall on the screen which is far from the slide by the distance D. These bright spots are separated by dark spots. The width of the central spot is $\ell$.

**0,5** **1-1-** Choose which one of the following statements is true:

**a-**In glass, light travels at greater speed than in air.

**b-**The angular separation is given by: $2\theta = \frac{\lambda}{a}$.

**c-** The frequency of the light emitted by a helium-neon laser is $\upsilon = 4,739.10^{14}\ Hz$ .

**d-** The angular separation increases when we use a violet laser beam instead of the red one.

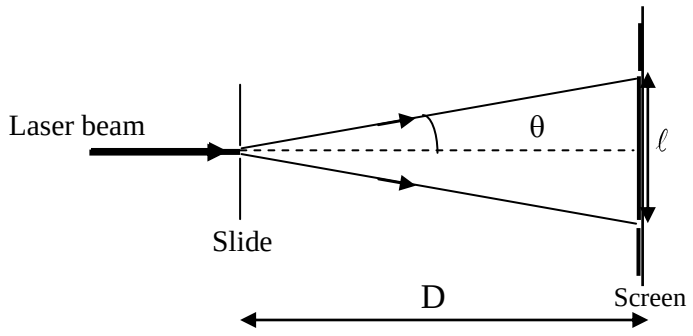



**Figure 1**

**0,75** **1-2-**In the case of the small angles, find out the expression of the width **a** in terms of D, $\ell$ and $\lambda$**.** For a distance $D = 1,5\,m$, we measure the width $\ell$ and we obtain $\ell = 3,4\,cm$. Calculate **a**.

**0,5** **1-3-** We change the distance between the slide and the screen by taking $D' = 3\,m$.
Calculate the value of the angular separation and the width of the central spot**.**

### 2- Study of the radiation emitted by the He-Ne laser:

**0,5** **2-1-** Calculate, in electronvolt (eV), the energy of the photon corresponding to the emitted red light.

**0,5** **2-2-** Figure 2 represents the energy levels of the neon atom.
When the helium (Ne) passes from the energy level $E_n$ to the energy level $E_p$, the radiation of wavelength $\lambda = 633\,nm$ is produced by the He-Ne laser.
Determine $E_n$ and $E_p$.

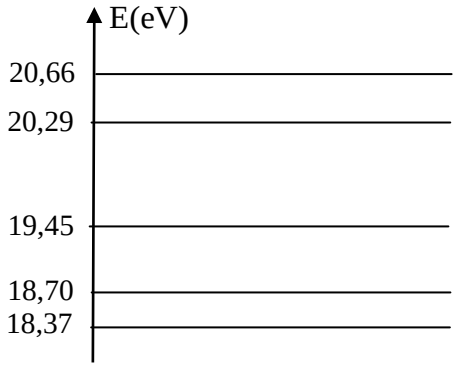



**Figure 2**

## Electricity :(5 points)

Many devices such as the integrated circuit, the operational amplifiers and the devices of emission and reception…, make use of components like capacitors, resistors and inductors.
This exercise aims to study:

- Charging and discharging of a capacitor over a resistor then over an inductor.
- Receiving an electromagnetic wave.

We take: $\pi=\sqrt{10}$ .

### 1-Charging a capacitor and its discharging over a resistor:

We set up the mounting shown in figure 1. This mounting consists of:

- An ideal power supply of electric current;
- A resistor of resistance R;
- A capacitor of capacitance C, without initial charge;
- A microammeter;
- A double switch K.

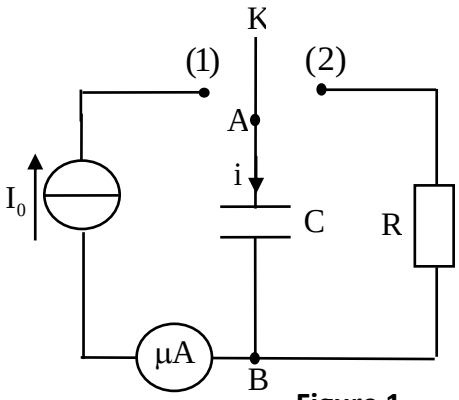


Figure 1

We put the switch in position (1) at an instant of time $t=0$.
The microammeter indicates $I_0=0,1\mu A$. An appropriate datalogger gives the curve which represents the variation of the charge q of the capacitor with the voltage $u_{AB}$ between its terminals (figure 2).

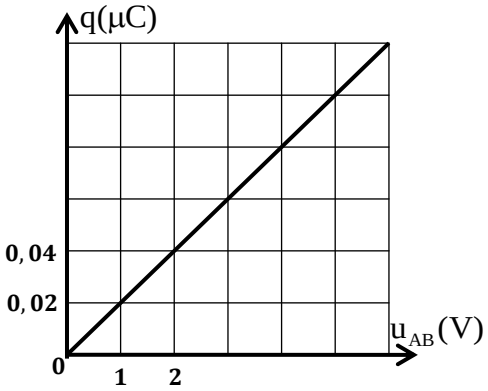


Figure 2

**0,25** **1-1**-Show that the value of the capacitance C of the capacitor is $C=20\,nF$.

**0,5** **1-2**-Determine the required duration to reach $u_{AB}=6\,V$ the voltage between the terminals of the capacitor.

**1-3-** When the voltage between the terminals of the capacitor reaches the value $u_{AB}=U_0$, we put the switch K in position (2) at an instant $t=0$ taken as a new origin of time. The curve in figure 3 represents the variation of $\ln(u_{AB})$ with time t; ($u_{AB}$ is expressed in V ).

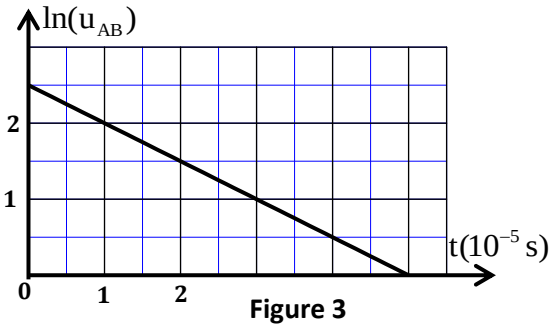


Figure 3

**0,25** **1-3-1**- Find out the differential equation of the voltage $u_{AB}(t)$.

**1** **1-3-2**- The solution of the differential equation is: $u_{AB}(t)=U_0e^{-\alpha t}$ where $\alpha$ is a positive constant, find out the values of $U_0$ and R .

**0,5** **1-3-3**- Determine the instant $t_1$ when the energy stored in capacitor equals 37% of its value at $t=0$.

### 2- Discharging the capacitor in an inductor:

We recharge the preceding capacitor, and then we set up the mounting shown in figure 4 which consists of this capacitor and:

- An inductor (coil) (b) of inductance L and of resistance r ;
- A resistor of resistance $R_0=12\Omega$ ;
- A switch K .

We switch the circuit and we visualise the voltage $u_{R_0}(t)$ between terminals of the resistor. We observe pseudo-periodic oscillations.

**0,5** **2-1-** Find out the differential equation of the voltage $u_{R_0}(t)$ between the terminals of the resistor.

**2-2** - To maintain the electric oscillations, we add in series in the circuit a power supply G which provides the circuit in generator convention by the voltage $u_G(t)=k.i(t)$ where $k$ is an adjustable parameter $(k>0)$.

When $k=20$ which is expressed in the international system of units, the voltage $u_{R_0}(t)$ becomes sinusoidal.

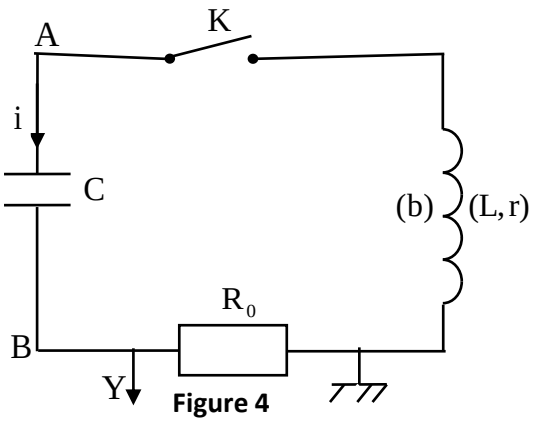


Figure 4

**0,25** **2-2-1-**Determine the value of $r$.

**0,5** **2-2-2-**The curve in figure 5 shows the variation with time of the magnetic energy $E_m$ stored in the inductor.

Find out the values of $L$ and $U_{c_{max}}$ the maximum voltage between terminals of the capacitor.

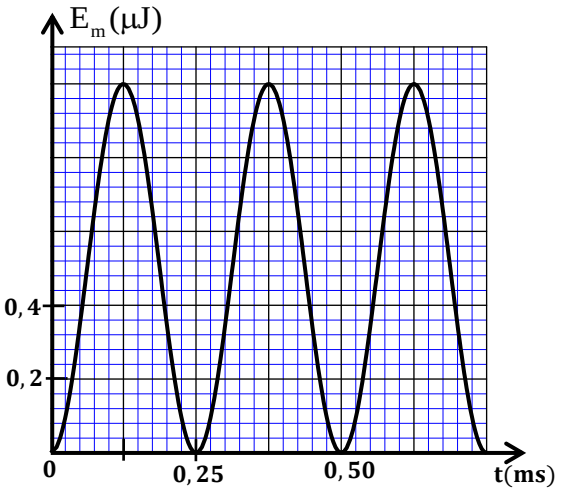


Figure 5

**3- Receiving an electromagnetic wave:**

To receive an AM (amplitude-modulated) electromagnetic wave of frequency $N_0=40\,kHz$, we use the simple apparatus shown in figure 6.

**0,25** **3-1-** Choose which one of the following statements is true:

**a-** The carrier wave frequency is lower than the modulating wave frequency.

**b-** The role of part 1 is to remove the direct component.

**c-** The role of parts 2 and 3 of the apparatus is to produce amplitude modulation.

**d-** In the receiving antenna, the electromagnetic wave generates an electric signal with the same frequency.

**0,5** **3-2-**We set up the bung circuit (LC circuit) by using a capacitor of capacitance $C_0$ and an inductor of inductance $L_0=0,781\,mH$.

Can we receive the wave of frequency $N_0=40\,kHz$ when $C_0=C=20\,nF$? Justify your answer.

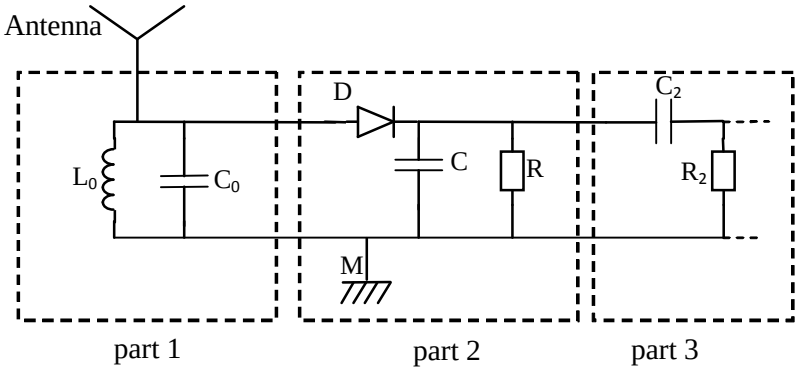


Figure 6

**0,5** **3-3-**To recover the envelope of the modulated wave, we use a capacitor of capacitance $C=20\,nF$ and a resistor of resistance $R=1k\Omega$. To achieve a high quality of the detection, we set up in parallel with the capacitor of capacitance $C$ another capacitor of capacitance $C_x$.

Find out the interval of the values of $C_x$ knowing that the frequency of the information signal is $N_i=4\,kHz$.

**Mechanics :(5,25 marks)**

**Part one and part two are independent**

## Part one: Study the falling motion of two objects

In this part, we study the falling motion of two objects (A) and (B) in the frame of reference $R(O,\vec{i},\vec{j})$ linked to the earth assumed Galilean. Point O is located on the ground (Figure 1).

The upthrust force (Archimedes' force) is negligible about other forces and we take the gravitational field strength $g=10\,m.s^{-2}$.

**1-Study the falling of an object with friction:**

At an instant assumed the origin of time ($t=0$), we liberate from the position H (figure 1), without initial velocity, an object $(A)$ with the center of inertia $G_A$ and of mass $m_A=0,5\,kg$.

In addition to its weight, the object $(A)$ obeys to a frictional fluid force (viscous force) $\vec{f}=-k.\overrightarrow{v_A}$ where $\overrightarrow{v_A}$ is the velocity of $G_A$ at one instant t and k is a positive constant.

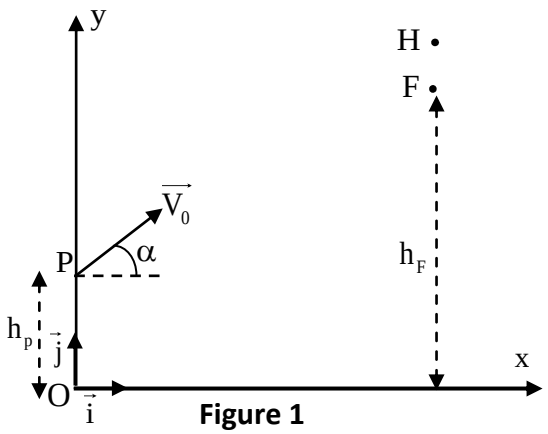


Figure 1

**0,5** **1-1-** Show that the differential equation of the component $v_{Ay}(t)$ on the y-axis $(Oy)$ of the velocity $\overrightarrow{v_A}(t)$ is written as: $\frac{dv_{Ay}}{dt}+\frac{1}{\tau}v_{Ay}+g=0$ where $\tau$ is the characteristic time of the motion.

**0,5** **1-2-**The curve in figure 2 represents the variation of $v_{Ay}(t)$ with time.

Determine $\tau$ and deduce the value of $k$.

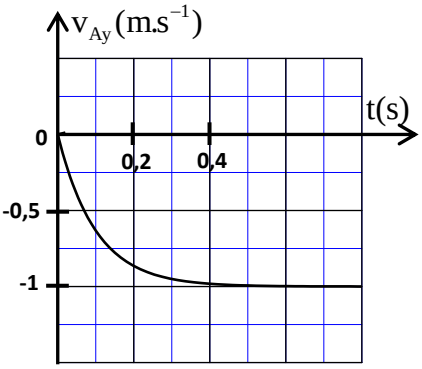


Figure 2

**0,5** **1-3-** Using the method of Euler, determine the value of $v_{Ay}(t_i)$ at an instant $t_i$ knowing that the value of the acceleration at the instant $t_{i-1}$ is $a_{Ay}(t_{i-1})=-4,089\,m.s^{-2}$ and that of the calculating step is $\Delta t=0,01s$.

**2-Study the motion of a projectile in the gravitational field:**

At an instant , when the centre of inertia $G_A$ of the object $(A)$ passes by the point F ,at the altitude $h_F=18,5\,m$ above the ground, a projectile $(B)$ of centre of inertia $G_B$ and of mass $m_B$ is thrown (projected) from a point P whose coordinates are $(0,h_p)$ with an initial velocity $\overrightarrow{V_0}$ at an angle $\alpha$ $(0<\alpha<\frac{\pi}{2})$ to the horizontal (figure 1). This instant assumed a new origin of time ($t=0$) of both motion of $(A)$ and that of $(B)$.

The frictional force on the projectile $(B)$ is negligible and we give: $h_P=1,8\,m$ ; $V_0=20\,m.s^{-1}$.

**0,5** **2-1-**Find out the parametric equations $x_B(t)$ and $y_B(t)$ of the motion of $(B)$ in terms of $\alpha$ and t.

**0,5** **2-2-**Determine the expression of the coordinates of point S, which is the maximum height of the path of $(B)$, in terms of $\alpha$.

**0,5** **3-**The coincidence of the two objects $(A)$ and $(B)$ is at S (at position S, we consider that $G_A$ coincides with $G_B$). Determine the angle α knowing that object $(A)$ passes by F with its terminal velocity and that the motions of $(A)$ and $(B)$ are in the same plane $(xOy)$.

## Part two: Study the motion of a physical pendulum

This part aims at determining of the gravitational field strength on a place and some physical quantities linked to the motion of the physical pendulum motion.

A physical pendulum consists of a homogenous rod OA its center of inertia G, of mass m and length L able to turn by its terminal O, around a fixed axis $(\Delta)$ (figure 1). Let's consider $J_\Delta$ the moment of inertia of the pendulum about the axis $(\Delta)$.

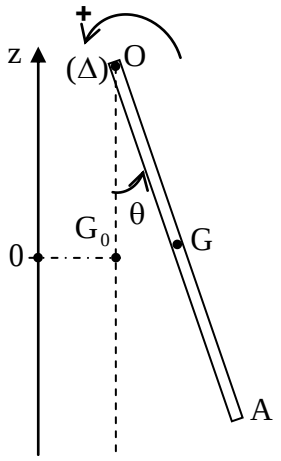


Figure 1

We study the motion of the pendulum in a frame of reference which is assumed Galilean.

We move the rod OA from its stable equilibrium position with a small angle $\theta_0$, then in the positive direction, we liberate this rod with an initial angular velocity at an instant t=0.

We locate the position of the pendulum at one instant t of time by the angular displacement $\theta$. When the pendulum passes by its equilibrium position, G coincides with $G_0$.

Assuming the gravitational potential energy to be zero $(E_{pp}=0)$ on the horizontal plane passes through $G_0$ (reference level). All frictions are negligible.

**Given:**
- Mass of the rod is $m=100\,g$;
- Length of the rod is $L=0{,}53\,m$;
- The expression of moment of inertia of the rod about the axis $(\Delta)$ is $J_\Delta=\frac{1}{3}m.L^2$;
- For the small angles; $\cos\theta\approx 1-\frac{\theta^2}{2}$ where $\theta$ is expressed in radian;
- We take $\pi^2=10$.

**0,5** **1-**Find out the expression of the gravitational potential energy of the physical pendulum at one instant of time t, in the case of the small oscillation amplitude, in terms of $\theta$, L, m and g the gravitational field strength.

**0,5** **2-**By using an energetic study, show that the differential equation of the motion is written as:

$$\frac{d^2\theta}{dt^2}+\frac{3g}{2L}\theta=0.$$

**3-**The solution of the differential equation is : $\theta(t)=\theta_m\cos\left(\frac{2\pi}{T_0}t+\varphi\right)$ where $T_0$ is the natural period of the pendulum.

The curve in figure 2 shows the evolution with time of the kinetic energy $E_k$ of the pendulum.

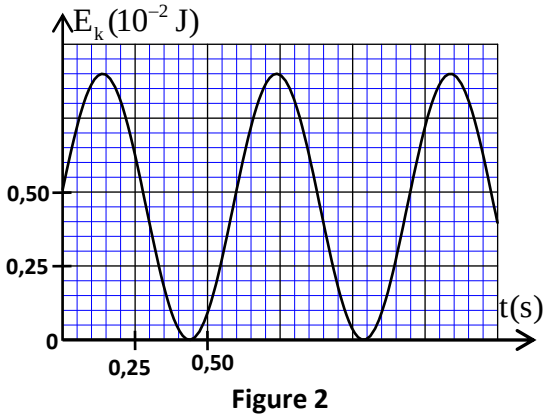


Figure 2

**0,5** **3-1-**Determine the value of g the gravitational field strength (acceleration free fall).

**0,5** **3-2-**Find out the value of the amplitude $\theta_m$ of the motion.

**0,25** **3-3-**Determine the value of $\varphi$.

# الامتحان الوطني الموحد للبكالوريا
## المسالك الدولية- خيار أنجليزية
## الدورة العادية 2017
## - عناصر الإجابة -

NR 30E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

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

| Chemistry (7 points) | | | |
|---|---|---|---|
| **Question** | **Answers** | **Marking scale** | **Question reference in the framework** |
| | **Part I** | | |
| **1-1-** | equation of titration reaction (use only one arrow). | **0,5** | -Write the equation of titration reaction (use only one arrow) |
| **1-2-** | $V_{BE}=20\,mL$ , $C=\frac{C_B.V_{BE}}{V_A}$ ; $C=4.10^{-2}\ mol.L^{-1}$ | **0,25+0,25** **0,25** | -Exploit the curve or the results of the titration. |
| **1-3-** | Check the value of p | **0,5** | |
| **1-4-** | Using the progress table , $HCOO^-$ is the predominant chemical specie ; Method , $pK_A \simeq 3,8$ . | **0,25** **0,25** **0,25+0,25** | -Draw the progress table of a reaction and exploit it. -Write and use the expression of the acid dissociation constant KA associated with the reaction of an acid with water. -Know the relationship pKA= -logKA. |
| **2-1-** | Equation of the reaction | **0,5** | -Write the equation of the acid-base reaction and identify the two pairs involved. |
| **2-2-** | Finding $x_f=\frac{\sigma.V_1}{\lambda_{HCOO^-}+\lambda_{H_3O^+}}$ . | **0,5** | -Draw the progress table of a reaction and exploit it.. -Use the relationship linking the conductance G of a solution part to the effective molar concentrations [Xi] of Xi ions in the solution. |
| **2-3-** | Finding the value of $\tau$ . | **0,5** | -Define the final progress rate of a reaction, and determine it using experimental data |
| **2-4-** | $pK_A=-\log\left(\frac{C.\tau^2}{1-\tau}\right)$ , $pK_A \simeq 3,8$ . | **0,5** **0,25** | -Write and use the expression of the acid dissociation constant KA associated with the reaction of an acid with water. -Know the relationship pKA= -logKA. |

| Part II | | | |
|---|---|---|---|
| **1** | b | **0,5** | -Give and use the expression of the reaction quotient Qr through the reaction equation.<br>-Know that the abundance of one reactant or the removing of one product displaces the equilibrium state of the system in the forward direction.<br>-Know that a catalyst is a chemical specie that increases the rate of a chemical reaction without changing the equilibrium state of the system.<br>-Define the half-life t1/2 of a chemical reaction.<br>-Know the expression of the volume rate of reaction.<br>-Explain qualitatively the reaction rate change using the plotted evolution's curves,. |
| **2** | Write the equation of the reaction using structural formulae<br>propyl methanoate | **0,5**<br>**0,25** | -Name the esters containing at most five carbon atoms.<br>-Write the esterification and the hydrolysis equation. |
| **3** | In this instant, the reaction has not reached yet the equilibrium state. | **0,75** | -Calculate the yield of a chemical transformation.<br>-Determine the composition of reaction mixture at a given time.<br>-Give and use the expression of the reaction quotient Qr through the reaction equation. |

| **Physics (13 points)** | | | | |
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| **Exercice 1** | **Question** | **Answers** | **Marking scale** | **Question reference in the framework** |
| **Waves(2,75 points)** | **1-1-** | c | **0,5** | -Know (Recall) and exploit the relationship: $n = \frac{c}{v}$<br>-Know (Recall) and exploit the relationship $\theta = \lambda/a$ ;<br>- Know the boundaries of wavelengths and their colours for the visible spectrum in the vacuum..<br>-Know (Recall) and exploit the relationship: $\lambda = \frac{c}{v}$.<br>-Exploit experimental measurements to verify the relationship $\theta = \lambda/a$ |
| | **1-2-** | Establish this relationship : $a = \frac{2\lambda D}{\ell}$, $a \simeq 55,8\,\mu m$ | **0,5**<br>**0,25** | |
| | **1-3-** | $\theta \simeq 1,13.10^{-2}$ rad<br>$\ell' \approx 6,8\,cm$. | **0,25**<br>**0,25** | |
| | **2-1-** | $E = \frac{hc}{\lambda}$ , $E = 1,96\,eV$ | **0,25+0,25** | -Know and exploit the relation $\Delta E = h.\nu$ .<br>- Use different units of mass, energy and the relationships between their units. |
| | **2-2-** | $E_n = 20,66\,eV$ ;<br>$E_p = 18,70\,eV$ . | **0,25**<br>**0,25** | |

| Exercice 2 | Question | Answers | Marking scale | Question reference in the framework |
|---|---|---|---|---|
| Electricity(5 points) | 1-1- | Finding $C=20\,nF$ | 0,25 | - Know and exploit the relationship q = C.u.<br>- Know the capacitance of a capacitor, its unit F and their submultiples $\mu F, nF$ and $pF$.<br>- Determine the capacitance of a capacitor graphically or by calculation.<br>- Know and exploit the relationship $i=\frac{dq}{dt}$ for a capacitor in receiver convention. |
| | 1-2- | Method , $\Delta t=1,2\,s$ | 0,25+0,25 | |
| | 1-3-1- | differential equation | 0,25 | - Find out the differential equation and verify its solution when the RC dipole is submitted to a step voltage. |
| | 1-3-2- | Method , $U_0 \simeq 12,2\,V$.<br>Method , $R=1k\Omega$ | 0,25+0,25<br>0,25+0,25 | -Determine the voltage expression $u_C(t)$ between capacitor terminals when the RC dipole is submitted to a step voltage, and deduce both the expression of the intensity current in the circuit and the capacitor charge.<br>- Know and exploit the time-constant expression.<br>- Exploit experimental documents in order to: determine the time-constant and charge duration. |
| | 1-3-3- | Method , $t_1=10\,\mu s$ . | 0,25+0,25 | - Know and exploit the expression of the electric energy stored in a capacitor. |
| | 2-1- | differential equation | 0,5 | -Know and exploit the relationship $i=\frac{dq}{dt}$ for a capacitor in receiver convention.<br>Know and exploit the relationship q = C.u.<br>- Know and exploit the voltage expression $u = r.i + L.\frac{di}{dt}$ between the inductor (coil) terminals using the receiver convention.<br>-Find out the differential equation for the voltage between the capacitor 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: $u_G(t)=k.i(t)$<br>-Determine the two characteristics of the inductor (the inductance L, the resistance r) exploiting experimental results. |
| | 2-2-1- | Finding $r=8\Omega$ . | 0,25 | |
| | 2-2-2- | $L=312,5\,mH$.<br>$U_{c_{max}}=10\,V$. | 0,25<br>0,25 | -Know and exploit the natural period .<br>- Know and exploit the expression of the electric energy stored in a capacitor<br>- Know and exploit the expression of the total energy in the circuit. |
| | 3-1- | d | 0,25 | -Know that in the receiving antenna, the electromagnetic wave generates an electric signal that has the same frequency.-<br>-Recognise the different stages of amplitude modulation and amplitude demodulation through their corresponding assembly schemes.<br>- Know the conditions allowing to get an amplitude modulation and a high quality detection envelope. |
| | 3-2- | yes , justification | 0,5 | - Know the selective role of the LC (bung circuit) for the modulated voltage.<br>-Know and exploit the natural period expression. |
| | 3-3- | Method , $5\,nF << C_x < 230\,nF$ . | 0,25<br>0,25 | - Know the conditions allowing to get an amplitude modulation and a high quality detection envelope. |

| Exercice 3 | | Question | Answers | Marking scale | Question reference in the framework |
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| Mechanics (5,25 points) | Part I | 1-1- | Method to find out the differential equation | 0,5 | - Apply Newton's second law to find out the differential equation of a solid's centre of inertia motion in frictional vertical fall.. |
| | | 1-2- | $\tau = 0,1s$ , $k = 5kg.s^{-1}$ | 0,25+0,25 | -Exploit the curve $v_G = f(t)$ to determine:<br>- Apply Newton's second law to determine the kinetic quantities $\overrightarrow{v_G}$ and $\overrightarrow{a_G}$ and dynamic quantities and exploit them |
| | | 1-3- | Method,<br>$v_i \approx -0,632\,m.s^{-1}$ | 0,25<br>0,25 | -Know and apply the Euler's method to solve approximately differential equation. |
| | | 2-1- | $x_B(t) = 20\cos\alpha.t$<br>$y_B(t) = -5t^2 + 20\sin\alpha.t + 1,8$ | 0,25<br>0,25 | - Apply Newton's second law in the case of a projectile to:<br>* deduce the parametric equations of motion and exploit them;<br>* establish the equation of the path (trajectory), find out the expressions of the range and the maximum height of the path and exploit them; |
| | | 2-2- | $x_S = 20\sin 2\alpha$,<br>$y_S = 20\sin^2\alpha + 1,8$ | 0,25<br>0,25 | |
| | | 3 | Méthod , $\alpha \simeq 60^\circ$ | 0,25+0,25 | |
| | Part II | 1 | Finding $E_p = \frac{mgL}{4}\theta^2$ | 0,5 | -Exploit the expression of the gravitational potential energy and the expression of the kinetic energy to determine the mechanical energy of the physical pendulum in the small oscillations case.<br>-Exploit the conservation of the mechanical energy of a physical pendulum in the small oscillations case.<br>-Determine the nature of the motion for a physical pendulum in the small oscillation amplitude case; then, write and exploit the equations of the motion $\theta(t)$ , $\dot{\theta}(t)$ and $\ddot{\theta}(t)$ .<br>-Know the meaning of the physical quantities involved in the expression of the time-equation $\theta(t)$ for the physical pendulum and determine them using the initial conditions.<br>-Establish the expression of the natural period for the physical pendulum.<br>-Know and exploit the expression of the natural period and the natural frequency for the physical pendulum in the small oscillation amplitude case.<br>-Exploit the diagrams $\theta(t)$ , $\dot{\theta}(t)$ and $\ddot{\theta}(t)$ to determine the characterizing quantities of the physical pendulum motion in the small oscillation amplitude. |
| | | 2 | Method | 0,5 | |
| | | 3-1- | Method, $g \simeq 9,81\,m.s^{-2}$ | 0,25+0,25 | |
| | | 3-2- | Method,<br>$\theta_m \simeq 0,26\,rad \simeq 15^\circ$ | 0,25<br>0,25 | |
| | | 3-3- | $\varphi \simeq 0,84\,rad \simeq 48^\circ$ | 0,25 | |