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الامتحان الوطني الموحد للبكالوريا
المسالك الدولية
الدورة الاستدراكية 2020
- الموضوع –

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المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
المركز الوطني للتقويم والامتحانات

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

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

* The literal formula must be given before the numerical application and the result must be accompanied by its unit.*

**The exercises can be treated separately according to choice of the candidate.*

The subject includes four exercises; one in Chemistry and three in Physics.

Exercise 1 : Chemistry (6,5 points)

***Part I* :** *Diiodine-Zinc electrochemical cell*

Part II : *Acid-base reactions*

Exercise 2 : Waves (2,5 points) – Nuclear transformations (2,25 points)

I- *Mechanical waves and electromagnetic waves*

II-*Activity of a radioactive sample*

Exercise 3 : Electricity (5,5 points)

Part I : Response *of RC dipole to an increasing step of voltage and studying a RLC*

Part II : *Study of an amplitude-modulated signal*

Exercise 4 : Mechanics (3,25 points)

Part I : *Motion of vertical fall of a ball in a viscous liquid*

Part II : *Motion of a projectile in the uniform gravitational field.*

Exercise 1 : Chemistry(6,5 points)

Part I and part II are independent

Part I : diiodine-Zinc electrochemical cell

We study the diiodine-Zinc electrochemical cell which involves the two pairs: $Zn^{2+}_{(aq)}/Zn_{(s)}$ and $I_{2(aq)}/I^-_{(aq)}$. We consist it of two half cells connected with a salt bridge (filter paper soaked in a solution of potassium chloride $K^+_{(aq)} + Cl^-_{(aq)}$).

The first half cell consists of Zinc electrode immersed in a volume $V=100\ mL$ of an aqueous solution of zinc sulphate $Zn^{2+}_{(aq)} + SO^{2-}_{4(aq)}$ of initial molar concentration $\left[Zn^{2+}_{(aq)}\right]_i = C_0 = 0{,}10\ mol.L^{-1}$. The second half cell consists of platinum (Pt) electrode immersed in a volume $V=100\ mL$ of a mixture (S) containing an aqueous solution of diiodine $I_{2(aq)}$ and an aqueous solution of potassium iodide $K^+_{(aq)} + I^-_{(aq)}$ whose initial molar concentrations in (S) are: $\left[I_{2(aq)}\right]_i = C_1 = 0{,}10\ mol.L^{-1}$ and $\left[I^-_{(aq)}\right]_i = C_2 = 5{,}0.10^{-2}\ mol.L^{-1}$.

The part immersed from the zinc electrode is in excess and when the electrochemical cell is operating the platinum does not undergo any reaction.

Given:

-The faraday constant: $1F = 9{,}65.10^4\ C.mol^{-1}$;

- The equilibrium constant of the equation of the reaction: $I_{2(aq)} + Zn_{(s)} \underset{(2)}{\overset{(1)}{\rightleftharpoons}} 2I^-_{(aq)} + Zn^{2+}_{(aq)}$ is $K = 10^{46}$ at $25^\circ C$.

We mount in series with the electrochemical cell a conductor (D), an ammeter (A) and a switch K.

At an instant of date $t_0 = 0$ we close the circuit, the ammeter indicates the flow of the electric current of constant intensity $I_0 = 70\ mA$.

1- Indicate by justifying the direction of spontaneous evolution of the chemical system.**(0,5pt)**

2- Write the equation of the reaction occurring at the cathode level. **(0,25pt)**

3- We let the electrochemical cell operating during $\Delta t = t - t_0$. To determine the amount of diiodine which has been consumed during the operation of the electrochemical cell, we titrate the remaining diiodine in the second half cell of the electrochemical cell by a colorless solution of sodium thiosulfate $2Na^+_{(aq)} + S_2O^{2-}_{3(aq)}$ of molar concentration in solute provided $C_r = 0{,}30\ mol.L^{-1}$. The volume of the solution of sodium thiosulfate poured at the equivalence is $V_E = 20{,}0\ mL$.

The equation of the reaction of the titration is written as : $I_{2(aq)} + 2S_2O^{2-}_{3(aq)} \longrightarrow 2I^-_{(aq)} + S_4O^{2-}_{6(aq)}$.

Show that the amount $n_c(I_2)$ of the diiodine consumed during the operation of the electrochemical cell: $n_c(I_2) = 7{,}0\ mmol$. **(0,75pt)**

4- Find out the expression of the operating time $\Delta t = t - t_0$ of the electrochemical cell in terms of I_0 , F and $n_c(I_2)$.

Compute its value. **(0,75pt)**

5-Calculate the molar concentration of the zinc ions in the first half cell just after the operating time $\Delta t = t - t_0$ of the electrochemical cell. **(0,5pt)**

Part II : Acid-base reactions

The carboxylic acids are organic compounds, which are used in the composition of several substances in our daily life such as medicines, flavor, food, etc…. In this part, we propose to determine the chemical formula of a carboxylic acid of general formula $C_nH_{2n+1}COOH$ (with n $\in$ IN) and to study certain reactions of this acid with other compounds.

Given: $M(C)=12\,g.mol^{-1}$; $M(H)=1g.mol^{-1}$; $M(O)=16\,g.mol^{-1}$.

We prepare an aqueous solution (S), of volume $V=500mL$, of a carboxylic acid by dissolving an amount of this pure acid of mass $m=2,3g$ in the distilled water.
We take a volume $V_A=10\,mL$ of the solution (S) which we titrates by an aqueous solution (S_B) of sodium hydroxide $Na^+_{(aq)}+HO^-_{(aq)}$ of molar concentration $C_B=0,10\,mol.L^{-1}$. The volume of the solution (S_B) poured at the equivalent point is $V_{BE}=10,0\,mL$.

1-Write by using the general formula of the acid, the equation of the reaction of the titration. **(0,5 pt)**
2- Determine the concentration C_A of the acid in the solution (S), and deduce that the chemical formula of this acid is HCOOH. **(0,75 pt)**
3-The pH of the solution (S) is $pH=2,38$.
3-1- Determine the final progress rate of the reaction. Conclude. **(0,5 pt)**
3-2- Determine the value of the ratio $\frac{[HCOO^-]_{eq}}{[HCOOH]_{eq}}$ **.(0,75 pt)**
3-3- Verify that $pK_A(HCOOH_{(aq)}/HCOO^-_{(aq)})=pK_{A1}\simeq 3,74$ **.(0,5 pt)**
4- We mixture a volume V_1 of the solution (S) with the same volume V_1 of an aqueous solution of sodium ethanoate $Na^+_{(aq)}+CH_3COO^-_{(aq)}$ of the same concentration C_A; the pH of the mixture is $pH=4,25$.
Find out the expression of the pH of the mixture in terms of pK_{A1} and $pK_{A2}=pK_A(CH_3COOH_{(aq)}/CH_3COO^-_{(aq)})$. Deduce the value of pK_{A2} **.(0,75 pt)**

Exercise 2 : Waves (2,5 points) – Nuclear transformations (2,25 points)

I- propagation of mechanical waves and electromagnetic waves

1- Give the number of correct statements from the following statements :(0,5 pt)
a- The ultrasonic waves are longitudinal waves.
b- The ultrasonic waves are electromagnetic waves.
c- The frequency of the ultrasonic wave varies from air to water.
d- If we double the value of the frequency of the sinusoidal in non dispersive medium, then the speed of the propagation is divided by 2.

2- Copy the number of the question on your copy and write next to it, among the four answers offered, the correct answer without adding any justification or explanation.

2-1- The correct statement is: **(0,25pt)**

- During the propagation of a progressive mechanical wave, there is a transfer of matter.
- A mechanical wave on the free surface of the water can transfer a floating object.
- A sound wave propagates in the vacuum.
- During the diffraction of periodic progressive mechanical, its frequency does not vary.

2-2- The sound emitted by a speaker is a (0,25pt)

- mechanical, longitudinal wave.
- electromagnetic, transverse wave.
- mechanical, transverse wave.
- electromagnetic, longitudinal wave.

3- A laser beam of frequency $f_1 = 4,76.10^{14}\,Hz$ illuminate a vertical slit of width **a**. We locate a perpendicular screen E to the direction of the beam, at the distance $D = 1,6\,m$ from the slit. We display an aspect of diffraction whose central spot has a width $\ell_1 = 8cm$.

We give $c = 3.10^8\,m.s^{-1}$ the speed of a light wave in the air and we limit ourselves in the case of small angular deviations where $\tan\theta \approx \theta$ with θ is expressed in radian.

3-1- Draw the schematic mounting and the figure of the diffraction showing the angular deviation θ. **(0,5pt)**

3-2- Find out the value of the width **a** of the slit**. (0,5pt)**

3-3- We change the beam laser by another light source emitting a monochromatic light of wavelength $\lambda_2 = 450\,nm$. How the width of the central spot of the figure of the diffraction will be modified? Justify your answer. **(0,5pt)**

II- Activity of the polonium

The polonium $^{210}_{84}Po$, discovered in 1898 by Pierre and Marie Curie, decays to a particle α.

The polonium 210 is very toxic. The maximum dose of the polonium 210 which the human body can support corresponds to an activity $a_{max} = 740\,Bq$.

Given:

- Extract of the periodic table:

$_{81}Ti$	$_{82}Pb$	$_{83}Bi$	$_{85}At$	$_{86}Rn$

- $m(^4_2He) = 4,00151u$; $m(Pb) = 205,930\,u$; $m(Po) = 209,9374u$;
- $1u = 931,5MeV.c^{-2} = 1,6605.10^{-27}kg$;
- $1MeV = 1,6.10^{-13}\,J$.

1- Write the equation of disintegration of the nucleus of polonium 210. **(0,25pt)**

2/2-1- Compute, in MeV, the energy $|E_1|$ released by the decay of the nucleus of the polonium.**(0,5pt)**

2-2- Deduce, in Joule, the energy $|E_2|$ released by the decay of mass $m = 10g$ of polonium 210.**(0,25pt)**

3- A laboratory receives a sample of polonium 210, after the duration of $\Delta t = 245h\ 37\,min$ after the date of its reception, we measure the activity of the sample, and we found that it decreased by 5%.

Determine, in days, the value of the half-time $t_{1/2}$ of polonium 210. **(0,5pt)**

4- Calculate, in grams, the maximum mass m_{max} of polonium 210 which the human body can safely support. **(0,75pt)**

Exercise3 : Electricity (5,5 points)

Part I and part II are independent

In part I of this exercise, we propose to determine the characteristic quantities of the elements of an electrical circuit, by studying the charge of a capacitance and its discharge through an inductor. In the part II, we will study an amplitude-modulated signal.

Part I : **Response of RC dipole to an increasing step of voltage and studying a RLC dipole**

1- Response of RC dipole to an increasing step of voltage

We set up the mounting shown in figure1 which consists of

- an ideal generator of voltage of e.m.f E ;
- a capacitor of variable capacitance C without initial charge;
- a resistor of resistance R ;
- A resistor of resistance R_1 ;
- An inductor of inductance $L=0,1H$ and a negligible resistance.
- A switch K .

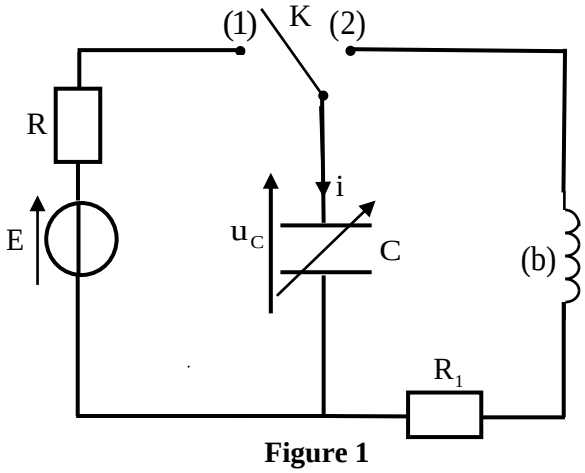


Figure 1

1-1- We adjust the capacitance of the capacitor to a value C and we put the switch, at the date t=0, at position (1).

1-1-1- Establish the differential equation verified by the current intensity $i(t)$. **(0,25 pt)**

1-1-2- The solution of this differential equation is written as $i(t)=A.e^{-\frac{t}{\tau}}$, with A is a constant and τ being the time-constant of the dipole RC.

Express $i(t)$ in terms of the parameters of the circuit and t.**(0,5 pt)**

1-2- The curves (a) and (b) of figure 2 represent the evolution of the intensity $i(t)$ of the current when we adjust the capacitance of the capacitor to a value C_1 then to a value C_2 with $C_2>C_1$.

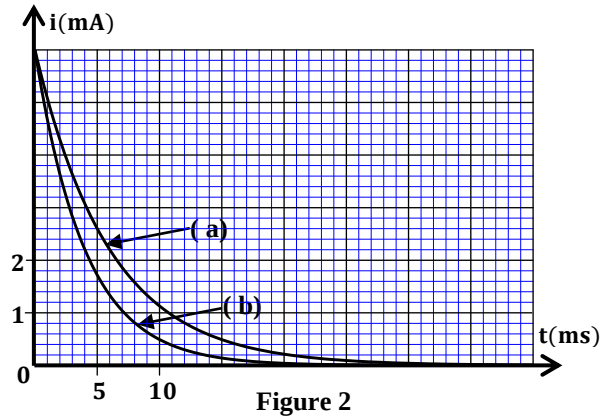


Figure 2

1-2-1- Indicate, justifying your answer, the curve which corresponds to capacitance C_1. **(0,25 pt)**

1-2-2- Show that $i\simeq 2,2\,mA$ for $t=\tau$. **(0,25 pt)**

1-2-3- The capacitance of the capacitor equivalent to a capacitor of capacitance C_1 assembled in parallel with a capacitor of capacitance C_2 is $C_e=10\,\mu F$. Show that $C_1=4\,\mu F$.**(0,75 pt)**

1-2-4- Determine the value of R and that one of E. **(0,5 pt)**

2- Discharge of a capacitor through an inductor

After the total charge of the capacitor of the capacitance C_1, we switch at an instant of time t (which we will take as new origin of dates $t=0$) the switch K to position (2). The curve in figure 3 represents the evolution, during the time, of the voltage $u_{R_1}(t)$ between the terminals of the resistor R_1. (T) represents the tangent of the curve at the instant of time t=0.

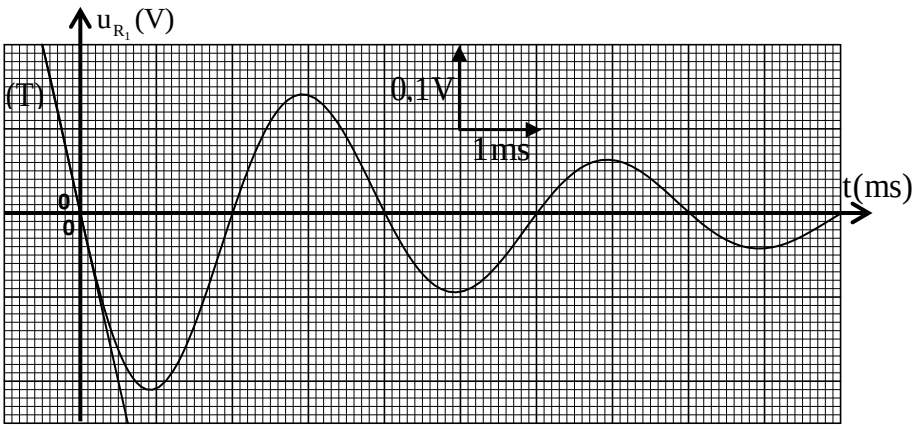


Figure 3

2-1- Establish the differential equation verified by $u_{R_1}(t)$. **(0,5 pt)**

2-2-Find out the value of R_1. **(0,75 pt)**

Part II : Study of an amplitude-modulated signal.

In order to obtain an amplitude-modulated signal, we use an integrated multiplier circuit X of characteristic constant $k=0,1V^{-1}$ (fig.4).

We apply at the input:

- E_1 : the voltage $v_p(t)=U_m.\cos(2\pi.10^5.t)$
- E_2 : the voltage $v_s(t)=s(t)+U_0$ with $s(t)=S_m.\cos(2\pi.10^3.t)$ and U_0 is the offset voltage.

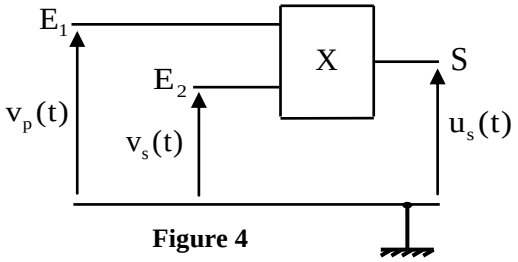


Figure 4

The output voltage $u_s(t)$ obtained is: $u_s(t)=k.(s(t)+U_0).v_p(t)$.

$u_s(t)$ can be written as :

$$u_s(t)=A.\left[\frac{m}{2}\cos(2\pi N_1.t)+\cos(2\pi F.t)+\frac{m}{2}\cos(2\pi N_2.t)\right]$$

with $A=k.U_m.U_0$, $N_1< F< N_2$, F is the frequency of the carrier wave and m is the modulation index.

1- Determine the value of N_1 and that one of N_2 .**(0,5 pt)**

2- Give the modulation index m in terms of S_m and U_0 .**(0,25 pt)**

3- We view the voltage $s(t)$ at the input X of the oscilloscope and the output voltage $u_s(t)$ at the input Y, and we eliminate the time base (XY mode).We thus obtain the oscillogram of figure 5 which represents $u_s(t)$ in function of $s(t)$.

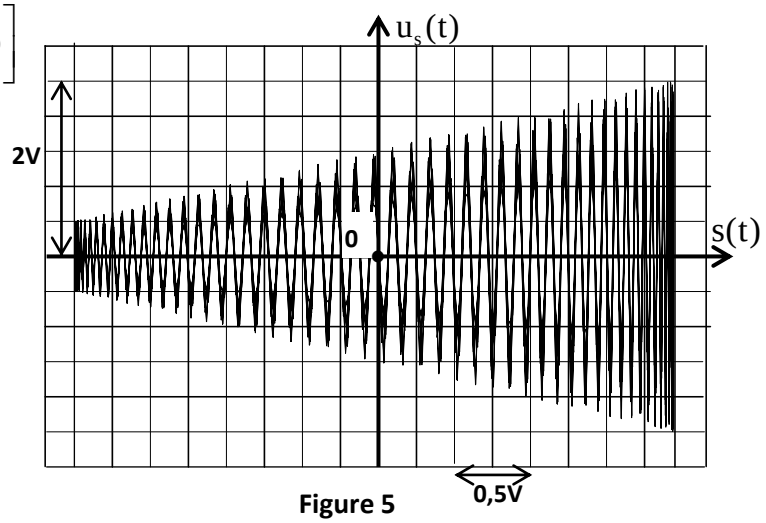


Figure 5

3-1- Determine graphically the modulation index m. **(0,5 pt)**

3-2- Determine the values of the voltages U_0 and U_m. **(0,5 pt)**

Exercise 4 : Mechanics (3,25 points)

Part I and part II are independent

Part I : ***Motion of vertical fall of a ball in a viscous liquid***

In this part, we study the motion of the center of inertia G of a homogeneous spherical ball**,** of mass m and radius r, in oil contained in a glass tube.

We study the motion of the center of inertia G in the orthonormal frame of reference $(O,\vec{k})$ linked to the earth assumed Galilean.

We locate the position of G at any moment by the vertical axis $(O,\vec{k})$ directed downwards. The origin of the axis coincides with the point O_1 .

At the instant of date t_0 , token as origin of dates $(t_0 = 0)$, we let go the ball without initial velocity from the point O_1 . (figure1)

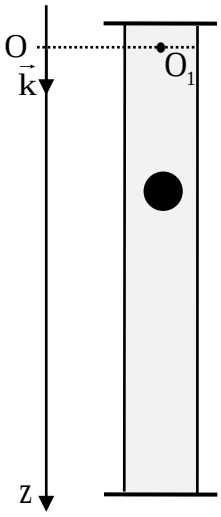


Figure 1

During its fall in the oil, in addition to its weight, the ball obeys to

- a frictional fluids force: $\vec{f} = -6\pi.\eta.r.v.\vec{k}$, where η is the viscosity of the oil, r is the radius of the radius of the ball and v is the velocity of G at an instant t ;
- The upthrust force (Archimedes' force) : $\vec{F} = -\rho_\ell.V_S.\vec{g}$ where g is the gravitational field strength, V_S is the volume of the ball and ρ_ℓ the density of the oil.

Given:

- the gravitational field strength $g = 9,81 m.s^{-2}$,
- the density of the oil: $\rho_\ell = 860 kg.m^{-3}$;
- the radius of the ball : $r = 6,3 mm$;
- the density of the ball : $\rho_S = 4490 kg.m^{-3}$.

Remember that the volume of the sphere of radius r is $V = \frac{4}{3}.\pi.r^3$.

1- By applying Newton's second law ; show that the differential equation of the motion of G verified by the velocity v is written as: $\frac{dv}{dt} + \frac{1}{\tau}.v = g\left(1 - \frac{\rho_\ell}{\rho_S}\right)$ with $\vec{v} = v\vec{k}$ and τ the characteristic time of the motion expressed in terms of the givens of the of the exercise. **(0,5pt)**

2- The terminal velocity v_ℓ of the fall of the ball is determined by an experimental study which consists of recording the motion of the ball in a glass tube of height $h = 90 cm$ and filled with the oil used.

The analysis of results of the registration yielded $v_{lim} \simeq 1,0 m.s^{-1}$.

Express the viscosity η in terms of v_{lim} and of givens of the exercise. Calculate its value. **(0,5pt)**

3- Calculate for $t = 7\tau$ the coordinate $z(t) = v_{lim}\left(t + \tau\left(e^{-\frac{t}{\tau}} - 1\right)\right)$. Explain why this tube of hight $h = 90 cm$ is suitable for the experimental measurement of v_{lim} **.(0,5pt)**

Part II : Motion of a projectile in the uniform gravitational field

In this part, we study the free fall of a projectile, of center of inertia G and mass m in a frame of reference $R(O,\vec{i},\vec{j})$ linked to a geocentric frame of reference assumed Galilean. We suppose that during the motion, the gravitational field is uniform.

At an instant chosen as origin of dates ($t=0$), we throw the projectile from the point O origin of the frame of reference with initial velocity $\overrightarrow{V_0}$ at an angle α with the horizontal plane and located in the (xOy) plane(figure 2) .

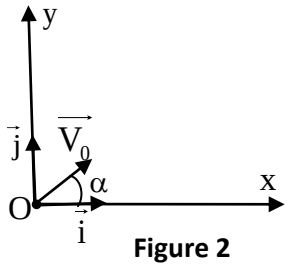


Figure 2

Given : $g=10\,m.s^{-2}$; $V_0=100\,m.s^{-1}$.

Remember that: $\frac{1}{\cos^2\alpha}=1+\tan^2\alpha$.

1- By applying Newton's second law ; establish the parametric equations of motion x(t) and y(t) of center of inertia G in terms of α and t . **(0,5 pt)**

2- Deduce the equation of the path of the projectile. **(0,5 pt)**

3- We keep the norm of $\overrightarrow{V_0}$ constant.

3-1- Find out the value or the values to give to angle α to reach a target (A) of coordinates $(x_A=400\,m;y_A=100\,m)$. **(0,5 pt)**

3-2- We vary the angle α, let (c) be the curve, in the plane (xOy), which limits the set of points that can be reached by this projectile. This curve (c) is called the parabola of safety.

Show that the equation of this curve (c) is written as : $y=-\frac{g}{2V_0^2}x^2+\frac{V_0^2}{2g}$. **(0, 25 pt)**

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