المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2019
-الموضوع-

RS28E

المادة	الفيزياء والكيمياء	مدة الانجاز	3
الشعبةأوالمسلك	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	المعامل	7

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

Literal expressions should be given before doing numerical calculations.

This exam paper consists of four exercises;

Exercise I (7 points)

- Study of the nickel – cadmium electrochemical cell
- Study of some reactions of the aspirin

Exercise II (2,5 points)

- Diffraction of light

Exercise III (5 points)

- Study of RL dipole and RLC series circuit
- Amplitude modulation

Exercise IV (5,5 points)

- Motion of a solid in the gravitational field
- Energetic study of the torsion pendulum

Marking scale

EXERCISE I (7 points)

Part 1 and Part 2 are independent.

Part 1: Study of the nickel-cadmium electrochemical cell

The functioning of the electrochemical cells is based on the principle of the conversion of a part of the chemical energy to an electric energy. In this part, we study the functioning principle of the nickel-cadmium electrochemical cell.

We perform the electrochemical cell using the following tools and substances:

- a beaker containing an aqueous solution of the nickel sulphate $Ni^{2+}_{(aq)} + SO^{2-}_{4(aq)}$ of initial concentration $C = 1 mol.L^{-1}$;
- a beaker containing an aqueous solution of the cadmium sulphate $Cd^{2+}_{(aq)} + SO^{2-}_{4(aq)}$ of initial concentration $C = 1 mol.L^{-1}$;
- a plate of the nickel and another one of the cadmium;
- a salt bridge.

In series, a resistor and an ammeter are connected between terminals of the electrochemical cell. An electric current of constant intensity I = 0,3A flows in this circuit.

Given :

- 1 F = $9,65.10^4$ $C.mol^{-1}$;
- Molar mass of nickel: M(Ni) = 58,7 $g.mol^{-1}$;
- The equilibrium constant associated to the reaction $Ni^{2+}_{(aq)} + Cd_{(s)} \underset{(2)}{\overset{(1)}{\rightleftharpoons}} Ni_{(s)} + Cd^{2+}_{(aq)}$ is $K = 4,5.10^5$.

0,5 **1.** Calculate the value of the initial reaction quotient $Q_{r,i}$ of the chemical system. Deduce the spontaneous direction of the chemical system

0,5 **2.** Give the cell diagram (Cell notation) of this electrochemical cell.

0,5 **3.** Write the chemical equation at each electrode.

0,5 **4.** This electrochemical cell works for a duration Δt = 5h. Calculate the change in mass Δm of the nickel during Δt.

Part 2: Study of some reactions of the aspirin

The acetylsalicylic acid, commonly called aspirin, is widely used around the world for its medicinal benefit as a pain reliever for several diseases.

In the first step, we suggest to determine the mass of aspirin $C_9H_8O_4$ in a tablet by titration;

In the second step, we study the temporal evolution of the reaction between hydrogencarbonate ion $HCO^-_{3(aq)}$ and the acetylsalicylic acid (aspirin) $C_9H_8O_4$.

Given:

- The molar mass of acetylsalicylic acid $M(C_9H_8O_4) = 180 g.mol^{-1}$.

I-Titration of an aqueous solution of the acetylsalicylic acid

We dissolve a tablet of the aspirin in distilled water. We obtain an aqueous solution S of acetylsalicylic acid of molar concentration C_A and of volume V = 278 mL including a quantity of mass m of this acid. We take a volume V_A = 10 mL of the solution S and we titrate it using the aqueous solution S_B of the sodium hydroxide of molar concentration $C_B = 10^{-2}$ $mol.L^{-1}$, by using suitable acid-base indicator.

0,5 **1.** Write the equation of titration.(We denote by AH the acetylsalicylic acid $C_9H_8O_4$ and by A^- its conjugate base)

2. The equivalence point is obtained by pouring a volume V_{BE}= 10 mL of the solution S_B.

0,5 **2.1.** Determine the concentration C_A of the solution S.

0,5 **2.2.** Show that m = 0,5g.

0,5 **3.** Which acid-base indicator of the ones given in the table below is the suitable for this acid-base titration? Justify

Acid-base indicator	Methyl yellow	Helianthine	Cresol red
pH range	2,9 – 4	3,1 – 4,4	7,2 – 8,8

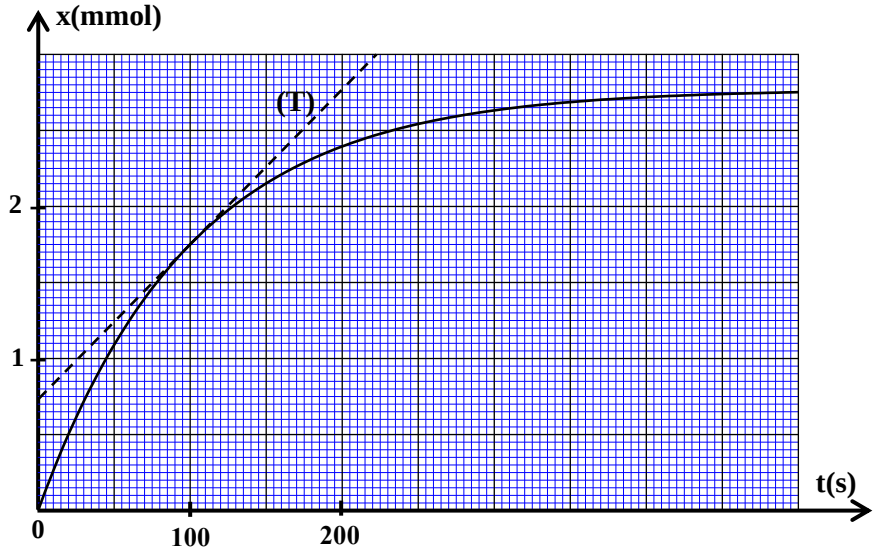
II-Study of the reaction between the hydrogencarbonate ion and the acetylsalicylic acid

The equation of the reaction between the hydrogencarbonate ion $HCO_{3(aq)}^-$ and the acetylsalicylic acid is written as:

$$C_9H_8O_{4(aq)} + HCO_{3(aq)}^- \rightarrow C_9H_7O_{4(aq)}^- + CO_{2(g)} + H_2O_{(l)}$$

To perform the temporal monitoring of this chemical reaction we pour into a flask, V=10 mL of the aqueous solution of the sodium hydrogencarbonate $Na_{(aq)}^+ + HCO_{3(aq)}^-$; its molar concentration is $\left[HCO_3^-\right]_0 = C = 0,5\,mol.L^{-1}$ then at t=0, we add a quantity of mass $m = 0,5g$ of the acetylsalicylic acid. (The volume of the reaction mixture is considered constant V=10 mL).

The curve in figure below represents the evolution of x the progress of this reaction.



0,5 **1.** Show that the initial amounts of substances for reactants are $n_0(C_9H_8O_4) \approx 2,8$ mmol and $n_0(HCO_3^-) = 5$ mmol.

0,5 **2.** Draw the progress table of this reaction.

0,5 **3.** Determine the value of the maximum progress x_{max}.

0,75 **4.** Calculate, in $mol.L^{-1}.s^{-1}$, the volumetric rate of reaction at the instant $t = 100s$. (Line (T) is the tangent of the curve at $t = 100s$)

0,75 **5.** Determine graphically $t_{1/2}$ the half-life of the reaction.

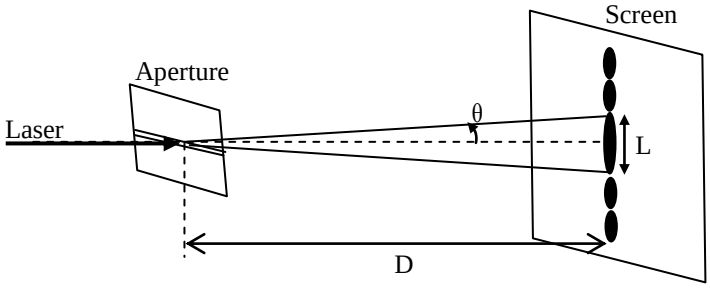
EXERCISE II (2,5 points)

Study of the diffraction of light

The diffraction phenomenon highlights the wave aspect of the light. Many applications in different fields are based on this phenomenon such as in the industry, the new technology, etc

This exercise aims at determining the wavelength of an emitted radiation by a Laser source.

A laser emits a red radiation of wavelength λ_R towards a horizontal aperture of width $a = 0{,}3\,mm$. A vertical diffraction pattern of bright spots appears on a screen at distance $D = 2\,m$. The width of the central spot is $L_R = 8{,}5\,mm$ (figure below).



0,5 **1.** Using the dimensional analysis, choose which of the following expressions of λ the wavelength of the diffracted wave is the correct one.

■ $\lambda = \frac{a.L.D}{2}$ ■ $\lambda = \frac{a.L}{2.D}$ ■ $\lambda = \frac{a}{L.D}$ ■ $\lambda = \frac{2.L}{a.D}$

2. For the two following questions, answer by true of false.

Over the diffraction of a monochromatic light:

0,5 **1.1.** The angular separation θ increases with increasing of the wavelength λ of the emitted radiation.

0,5 **1.2.** The width L the central spot is proportional to **a** the width of the aperture.

0,5 **3.** Determine the wavelength λ_R of the emitted radiation of this laser source.

0,5 **4.** We substitute the red radiation source by another one of blue radiation of wavelength $\lambda_B = 450nm$. Compare the widths L_R and L_B successively lengths of red and blue central spots.

EXERCISE III (5 points)

Part 1 and 2 are independent.

Capacitors and inductors play a vital part in most devices used in our lives such as thermistor sensors, alarms and medical diagnostics, etc

This exercise aims, in the first part, at determining the physical quantities of a capacitor and an inductor and, in the second part, at studying the amplitude modulation.

Part 1: Study of the RL dipole and the RLC series circuit

I – Study of the RL dipole

We perform the set-up sketched in figure 1 which consists of:

- an ideal power supply of electromotive force $E = 10\,V$;
- a resistor of resistance $R = 40\,\Omega$;
- an inductor of inductance L and of resistance r ;
- a switch K.

We switch on K at an instant taken as an origin of time (t = 0).

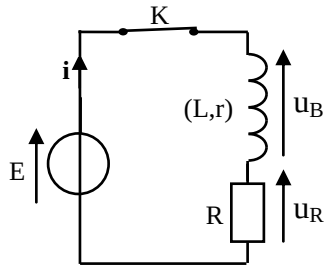


Figure1

Using an appropriate datalogger, we visualise two curves in figure 2 which represent the evolution of both the voltage between terminals of the resistor and that of the voltage $u_B(t)$ between terminals of the inductor.

Line (T) represents the tangent of the curve (2) at t=0.

0,5 **1.** Which curve (1) or (2) represents the voltage $u_R(t)$? Justify your answer.

0,5 **2.** Show that the differential equation verified by $u_R(t)$ is written as: $\frac{du_R}{dt} + \left(\frac{R+r}{L}\right)u_R = \frac{R.E}{L}$

0,25 **3.** Deduce that, in the steady state, the voltage between terminals of the resistor is given by : $U_R = \frac{R.E}{(R+r)}$

0,5 **4.** Calculate the value of r.

0,25 **5.** Find graphically the value of the time-constant τ.

0,25 **6.** Check that $L = 0,5\,H$.

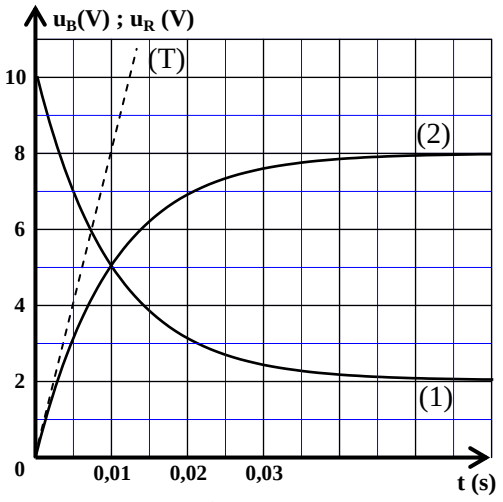


Figure 2

II- Study of the RLC series circuit

We charge totally a capacitor of capacitance C; then, in series, we set up this capacitor with the previous inductor and resistor at an instant (t=0) taken as an origin of time (figure 3).

The curves in figure 4 represent the evolution of $u_C(t)$ the voltage between terminals of the capacitor and i(t) the intensity flowing in the circuit.

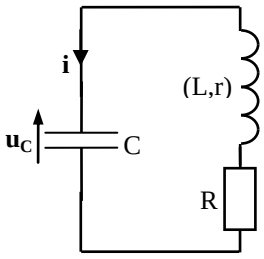
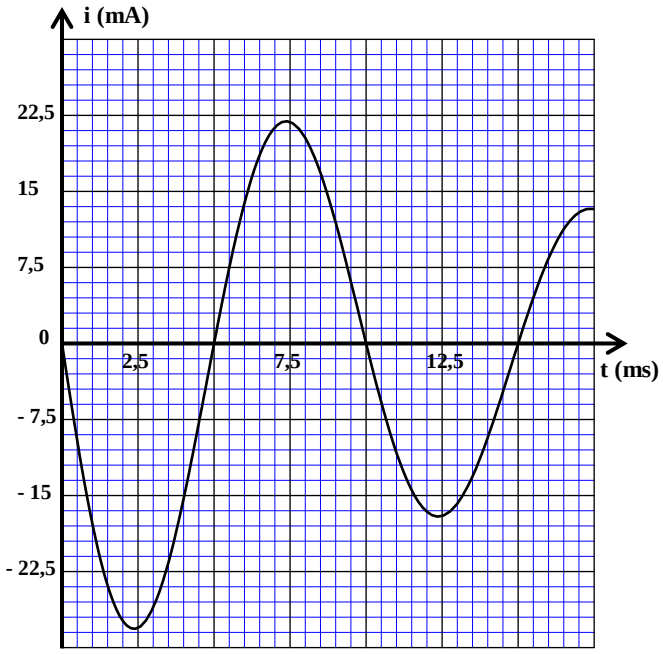


Figure 3

0,25 **1.** Name the state of oscillations in this case.

0,5 **2.** Assuming that the period is the same as the natural period T_0 of the electric oscillator, determine the value of the capacitance C. (take $\pi^2 = 10$).

0,75 **3.** Using the two curves in figure 4, calculate the total energy E_{t1} of the circuit at the instant $t_1 = 9\,ms$.



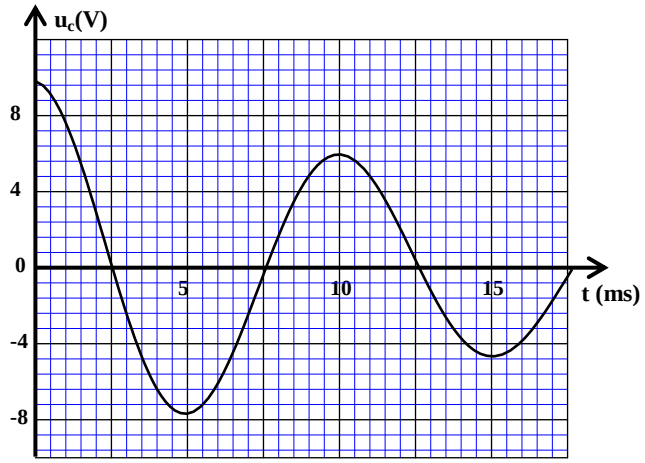


Figure 4

Part 2: Amplitude modulation

To get a sinusoidal amplitude modulated signal, we perform the set-up sketched in figure 5, where X is an integrated circuit of inputs E_1 and E_2 and of output S.

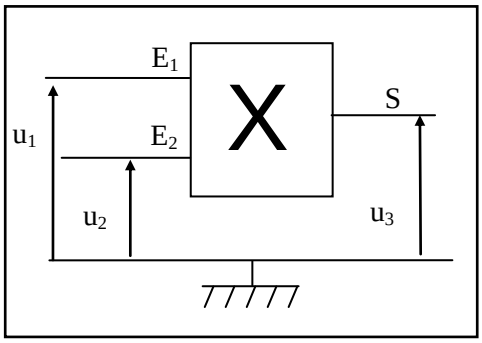


Figure 5

we apply:

- at E_1 the voltage $u_1(t) = U_0 + U_1\cos(2\pi f_1.t)$ where U_0 the DC component of the voltage.
- at E_2 the voltage $u_2(t) = U_2\cos(2\pi f_2.t)$.

The amplitude modulated voltage at the output S of the circuit is $u_3(t) = 0,1\left[0,6\cos(2\pi 10^4.t) + 0,8\right]\cos(6\pi 10^5.t)$

0,5 **1.** Determine the values of F_c the frequency of the carrier voltage and f_m the frequency of the modulating signal.

0,25 **2.** Calculate m the modulation index.

0,5 **3.** Is the modulation well done? Justify your answer.

EXERCISE IV (5,5 points)

Parts 1 and 2 are independent.

Part 1: Motion of a solid in the gravitational field

The study of a solid motion in the gravitational field allows us to determine specific quantities of this motion.

The aim of this part is the study the motion of a ball in the uniform gravitational field.

A ball of mass m is thrown upward vertically, with an initial velocity $\vec{V}_0$, at an instant taken as an origin of time (t=0), from a point A of altitude h=1,2m to the ground. We study the motion of G the center of inertia of the ball in a frame of reference assumed Galilean. We locate the position of G at an instant t in the coordinate system $(O, \vec{k})$ by the applicate z (Figure 1).

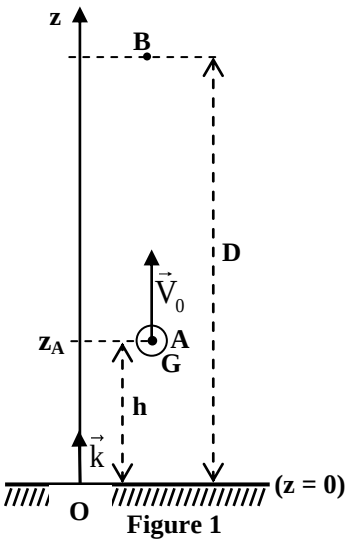


Figure 1

Assuming that the upthrust (Archimedes' force) and the frictional forces are negligible.

0,5 **1.** Define the free fall.

0,5 **2.** Applying Newton's second law, find out the differential equation verified by the component of the velocity V_Z of Gthe center of inertia.

0,5 **3.** Show that the parametric equation of the motion of G is written as : $z = -\frac{1}{2}g t^2 + V_0 t + h$

0,75 **4.** The curve in figure 2 represents the variations of V_Z as a function of time.

By using the curve in figure 2, write the numerical expression of the component $v_Z = f(t)$ as a function of time.

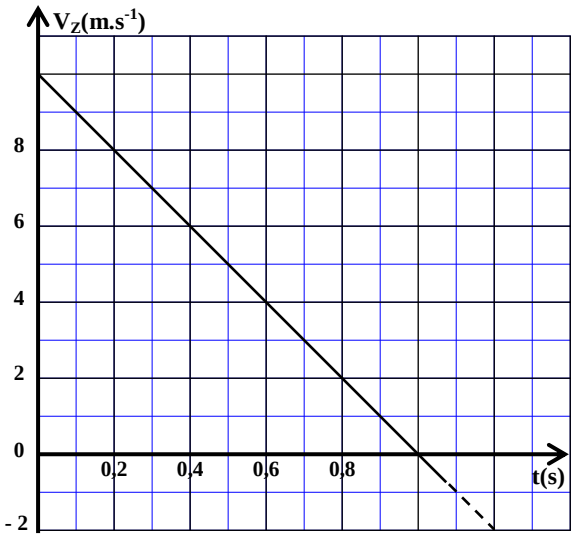


Figure 2

0,5 **5.** Over this upwardmotion the center of inertia G passes by the point B of altitude D to the ground with the speed $V_B = 3\,m.s^{-1}$ (Figure1). Show that $D = 5,75\,m$.

0,75 **6.** The ball is thrown now upward vertically, but with another initial velocity of $V_0' = 8\,m.s^{-1}$, at an instant taken as a new origin of time (t=0), from the same point A. Does the ball reach the point B? Justify your answer.

Part 2: Energetic study of the torsion pendulum

This part aims at determining the torsion constant of the metal wire using the energetic study of the torsion pendulum.

A torsion pendulum is consisted of a homogenous disc S supported by its center of inertia to a vertical metal wire of torsion constant C (figure 3).

We turn horizontally the disc to its equilibrium position in the positive direction by the angle $\theta_m = 0,5\,rad$ around the axis (Δ) whose direction is the same as the direction of the metallic wire, then we release it without velocity at an instant taken as origin of time (t=0). The pendulum makes a sinusoidal rotation.

We study the motion of the torsion pendulum in a geocentric frame of reference assumed Galilean. At an instant t, the angular displacement is θ.

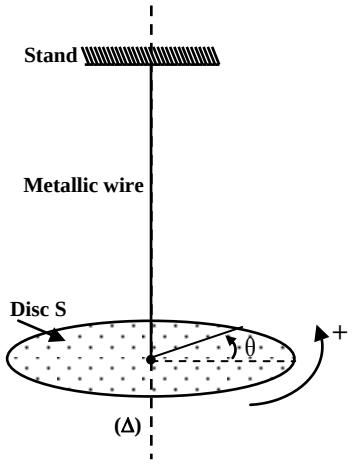


Figure 3

We assume that the gravitational potential energy to be zero on the horizontal plane including the disc and the equilibrium position of the disc (θ=0) the torsional potential energy to be zero.

The curve in figure 4 represents the variation of the torsional potential energy E_{pt} as a function of time.

Using the curve in figure 4,

0,75 **1.** Determine the maximum value of the torsional potential energy $E_{pt\,max}$ then deduce the value the torsion constant C.

0,5 **2.** Knowing that the mechanical energy E_m is conserved. Show that $E_m = 0,05\,J$.

0,75 **3.** Find the value of the kinetic energy of the pendulum E_{k1} at the instant $t_1 = 0,3\,s$.

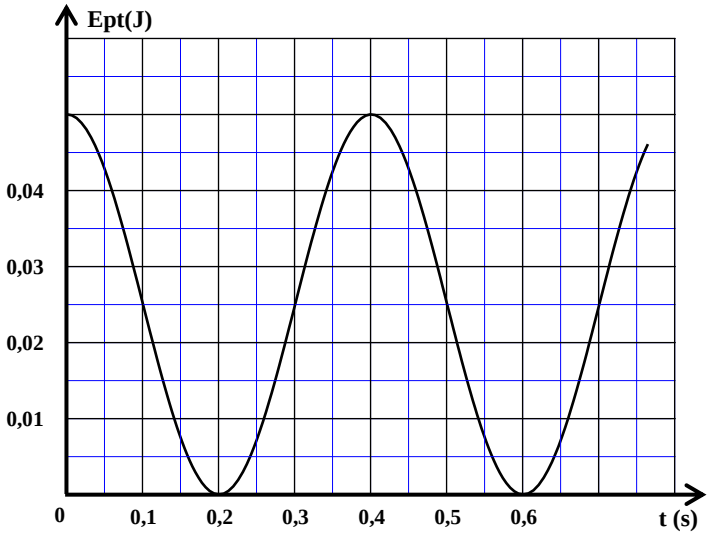


Figure 4