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

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

المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية مسلك العلوم الفيزيائية (خيارإنجليزية)	المعامل	7

The use of a non-programmable scientific calculator is allowed

Literal expressions should be given before doing numerical calculations

This exam paper consists of five exercises

EXERCISE 1 (7 points)

- Study of the aqueous solution of ammonia
- Study of the electrochemical cell of silver-chromium

EXERCISE 2 (3 points)

- Propagation of waves.

EXERCISE 3 (2,5 points)

- Disintegration of the polonium 210.

EXERCISE 4 (5 points)

- Response of RL dipole to a step voltage.
- Study of damping and maintaining oscillations in a RLC series circuit

EXERCISE 5 (2,5 points)

- Study of the vertical falling motion of a ball in a viscous liquid

Marking scale

EXERCISE 1 (7 points)

Part 1 and part 2 are independent

Part 1 : Study of the aqueous solution of ammonia

Ammonia NH_3 is a gas which dissolves in water to give a basic aqueous solution of ammonia. Some commercial aqueous solutions of ammonia can be used, after dilution, as cleaning products.

In this part, we propose studying the aqueous solution of ammonia.

An aqueous solution S_b of ammonia of volume V can be made by diluting 100 times a commercial solution S_0 of concentration C_0.

Given :

- All measurements are made at 25°C ;
- The ionic product of water $K_w = 10^{-14}$.

1. Titration of the solution S_b

We carry out the pH-metric titration of a volume V_b = 15 mL of the solution S_b of concentration C_b by using an aqueous solution S_a of the hydrochloric acid $H_3O^+_{(aq)} + Cl^-_{(aq)}$ of concentration $C_a = 10^{-2}\,mol.L^{-1}$.

The curve in figure 1 shows the pH changes of the mixture as a function of the volume V_a added of S_a. ($pH = f(V_a)$).

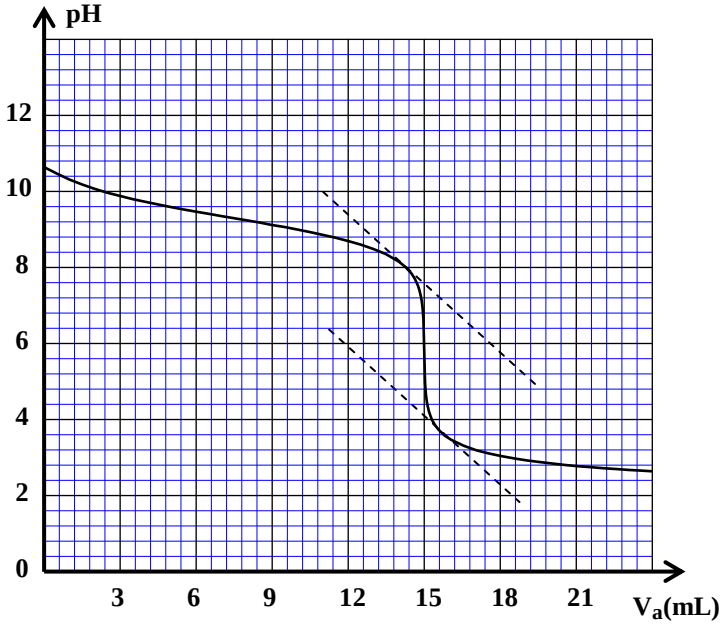


Figure 1

0,5 **1.1.** Write the reaction equation of this titration.

0,5 **1.2.** Write at equivalence point the relationship between C_b, C_a, V_b and V_{aE} which is the volume added of the solution S_a at equivalence point.

0,5 **1.3.** Show that the concentration C_b is $C_b = 10^{-2}mol.L^{-1}$ then deduce the value of C_0.

0,5 **1.4.** Choose from the following acid-base indicators the appropriate one for this titration. Justify your answer.

Indicator	Methyl orange	Methyl red	Phenolphtalein
pH-range	3,1 – 4,4	4,2 – 6,2	8,2 – 10

2. Study of the solution S_b

The measurement of the pH of the aqueous solution S_b gives pH = 10,6.

0,5 **2.1.** Write the reaction equation of the ammonia with water.

0,75 **2.2.** Calculate the effective molar concentration of the hydroxide ions HO^- in the solution S_b.

0,5 **2.3.** Calculate the final progress rate τ of this reaction.

0,5 **2.4.** Check that the reaction quotient at equilibrium is $Q_{r,éq} = 1{,}65.10^{-5}$.

0,5 **2.5.** Deduce the value of pK_A of the pair NH_4^+/NH_3.

Part 2 : Study of the electrochemical cell silver-chromium

In this part, we propose studying an electrochemical cell.

This electrochemical cell consists of :

- an electrode of chromium (Cr) immersed in the aqueous solution of the chromium (III) nitrate $Cr^{3+}_{(aq)} + 3NO^{-}_{3(aq)}$;
- an electrode of silver (Ag) immersed in the aqueous solution of the silver nitrate $Ag^{+}_{(aq)} + NO^{-}_{3(aq)}$;
- a salt bridge connects these two solutions.

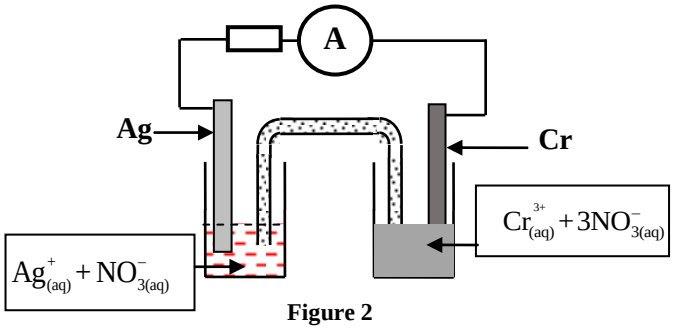


Figure 2

In series a resistor and an ammeter are connected between terminals of the electrochemical cell (figure 2). The ammeter indicates the flow of an electric current of constant intensity through the circuit.

After a period of time Δt of the functioning of the electrochemical cell, we observe a deposit on the silver electrode but the chromium electrode decreases in mass.

Given :

- The molar mass of the chromium is M(Cr) = 52 $g.mol^{-1}$;
- 1F= 96500 $C.mol^{-1}$.

0,5 **1.** Determine the anode of this electrochemical cell. Justify.

0,5 **2.** Represent the cell diagram of this electrochemical cell.

0,75 **3.** Write half-equations at electrodes and the overall equation during the functioning of this electrochemical cell.

0,5 **4.** Knowing that the quantity of charge transferred by this electrochemical cell during the period of time Δt is $Q = 5,79C$, calculate the change in mass Δm of the chromium electrode.

EXERCISE 2 (3 points)

Propogation of waves

I - Copy on your answer sheet the number of the question and write the letter of the correct answer from the suggested statements.

0,25 **1.** During the propagation of a mechanical wave there is

A	transport of matter and no transfer of energy.	**C**	no transport of matter and no transfer of energy.
B	no transport of matter and transfer of energy.	**D**	transport of matter and transfer of energy.

0,25 **2.** A mechanical wave is called transverse when

A	the direction of the disturbance is the same as the direction of the propagation.	**C**	the direction of the disturbance is perpendicular to the direction of the propagation.
B	it propagates in the vacuum.	**D**	the propation is done without damping.

0,25 **3.** A sound wave is

A	an electromagnetic wave.	**C**	a longitudinal mechanical wave.
B	a tansverse mechanical wave.	**D**	a wave that travels in vacuum.

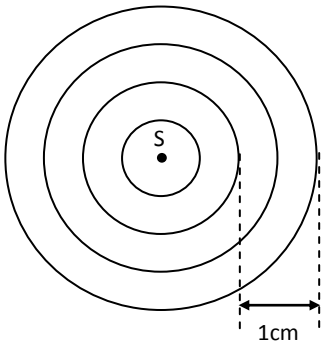
0,25 **4.** During the diffraction of a wave,

A	there is a change in the frequency.	**C**	there is a change in the wave speed.
B	there is a change in the wavelength.	**D**	there are no changes in the frequency, in the wavelength and in the wave speed.

0,25 **5-** We consider a point M from the surface of the water where a progressive wave propagates. This point M repeats the same motion of the source S with a time delay τ.
The relationship between the elongation of M and the elongation of S is:

A	$y_M(t) = y_s(t+\tau)$	**C**	$y_M(t) = y_s(t+2\tau)$
B	$y_M(t) = y_s(t-2\tau)$	**D**	$y_M(t) = y_s(t-\tau)$

II –The source S of a vibrator produces a sinusoidal progressive wave of frequency N across the surface of the water.
The wave propagates without damping and without reflection with a wave speed $v = 0{,}25 m.s^{-1}$.
The figure on the right represents the aspect of the surface of the water at an instant t_1.
The circular ripples illustrates crests.



0,5 **1-**By exploiting the figure on the right, determine the value of the wavelength λ .

0,5 **2-**Find the value of the frequency N of this wave.

0,75 **3-**We consider a point M far from S by d = 5cm. Calculate the time delay τ between motions of S and M.

EXERCISE 3 (2,5 points)

Disintegration of the polonium 210

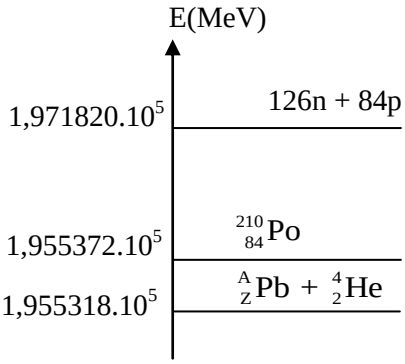
The polonium is a rare radioactive metal which was discovered by the scientist Pierre Curie in 1898.
This metal of symbol Po and atomic number 84 is radioactive. Polonium 210 is the only isotope existing in nature. A nucleus of polonium 210 decays into a nucleus of lead ${}^{A}_{Z}Pb$ by the emission of an α-particle.

Given :

- The half-life of the polonium 210 is $t_{1/2}$ = 138 days;
- $1u = 931{,}41\ MeV/c^2$; $1\ u = 1{,}66\ 10^{-27}$ kg.

0,5 **1-**Write the equation of the disintegration of the polonium 210 by determining A and Z.

2-By using the energy diagram on the right, calculate:



0,5 **2-1-**the energy released (produced) E_{pro} during the disintegration of the polonium 210 nucleus.

0,5 **2-2-**in kilogrammes (kg), the mass defect Δm of the polonium 210 nucleus.

0,5 **3-** Calculate in s^{-1} the decay constant λ of the polonium 210.

0,5 **4-**At t=0, the activity of a sample of Polonium 210 nuclei is $a_0 = 3{,}5.10^{11}$ Bq.
Determine, in days, the instant of time $t_1$when the activity of this sample will be $a_1 = 3{,}7.10^4$Bq.

EXERCISE 4 (5 points)

Many electric and electronic devices are made of capacitors and inductors as essential components.

This exercise aims at studying:
- the response of RL dipole to a step voltage.
- the discharging of a capacitor in a RL dipole
- the maintaining of oscillations in a RLC series circuit

I- The response of RL dipole to a step voltage.

We build the set-up sketched in figure 1.

This set-up includes :
- an inductor of inductance L and of resistance r ;
- a resistor of resistance $R = 90\,\Omega$;
- a generator of electromotive force E et and of negligible internal resistance;
- a switch K.

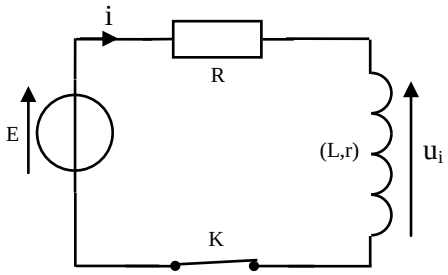
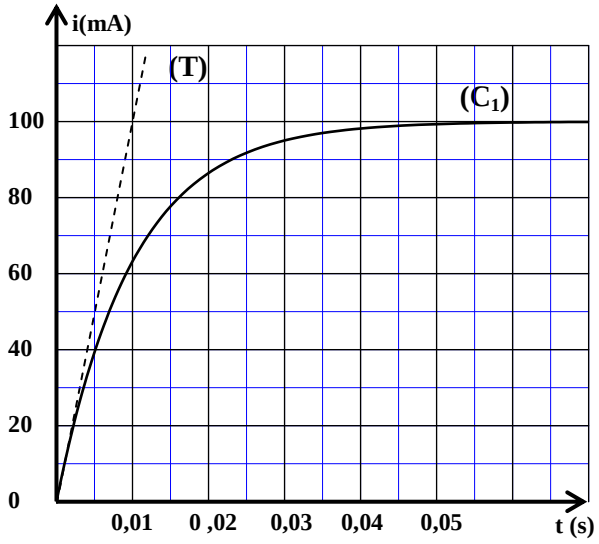


Figure 1

We switch on the circuit at an instant of time t = 0.

A datalogger leads to visualize curves (C_1) and (C_2) which represent successively the evolution of the intensity of the electric current i(t) and the evolution of the voltage $u_i(t)$ between terminals of the inductor.

The line (T) represents the tangent of the curve (C_1) at t = 0 (figure 2).



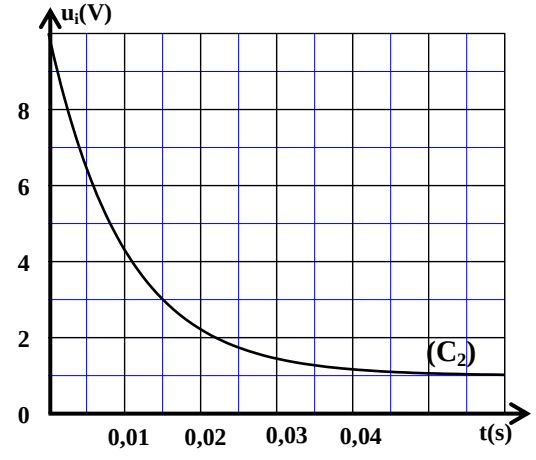


Figure 2

0,5 **1**-Show that the differential equation verified by the intensity of the electric current i(t) is written as : $\frac{di}{dt}+\frac{R+r}{L}.i=\frac{E}{L}$.

0,5 **2**-By exploiting curves (C_1) and (C_2) in their both steady states, determine the value of r.

0,5 **3**- Check that L = 1H.

II - Discharging a capacitor in a RL dipole

At an instant taken as origin ot time t=0, in series with the previous inductor and a resistor of resistance $R = 90\,\Omega$, we connect a fully charged capacitor of capacitance C (figure 3).
The curve in figure 4 gives the evolution of the voltage $u_C(t)$ between terminals of the capacitor.

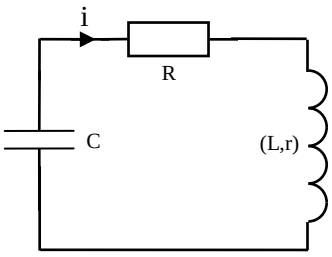


Figure 3

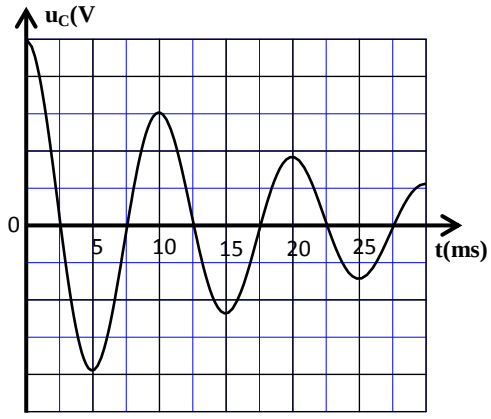


Figure 4

0,25 **1**-Which state of oscillations is shown in figure 4 ?

0,5 **2**-Find out the differential equation verified by the voltage $u_C(t)$.

0,5 **3**- Calculate the value of the capacitance C of the capacitor by assuming that the pseudo-period is equal to the natural period. We take $\pi^2 = 10$.

III -Maintaining oscillations in a RLC series circuit

To maintain the oscillations in the previous circuit of the figure 3, we connect in series a generator G providing the circuit by a voltage which is proportional to the intensity of the electric current as $u_G(t) = k.i(t)$ (Fig. 5).
The curve in figure 6 shows the evolution of the intensity i(t) in the circuit where $k = k_0$.

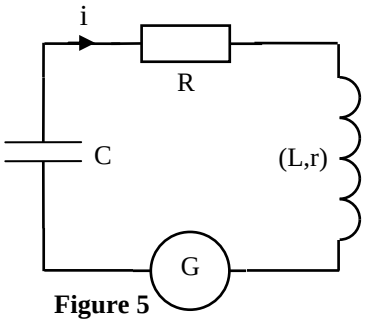


Figure 5

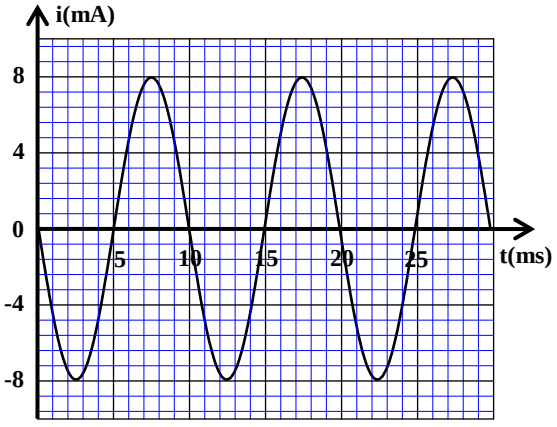


Figure 6

0,5 **1**-Determine the value of k_0.

0,75 **2** –Knowing that the expression of the intensity i(t) in the circuit is written as :

$$i(t) = I_m \cos\left(\frac{2\pi}{T_0}.t+\varphi\right)$$

Determine the values of I_m, T_0 and φ.

0,5 **3**-Calculate the total energy E_t of the circuit.

0,5 **4**-Find the value of the electric energy E_{e1} stored in the capacitor at the instant $t_1 = 16\,ms$.

EXERCISE 5 (2,5 points)

Study of the vertical falling motion of a ball in a viscous liquid

We suggest studying the vertical falling motion with friction in a viscous liquid of a homogeneous ball of mass m.

By using a camera and an appropriate software, we monitor the evolution of the velocity of G the center inertia of the ball during its falling through the viscous liquid.

We study the motion of G in a frame of reference assumed Galilean.

We locate the position of G at an instant t of time by its ordinate y on the downward y-axis $(O, \vec{j})$ (figure1).

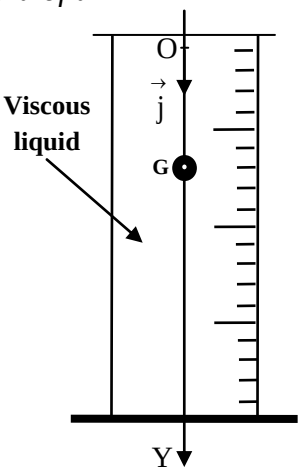


Figure 1

We model the viscous frictional forces by $\vec{f} = -kv.\vec{j}$ where v is the velocity of G at an instant t and k is a positive constant.

The upthrust force (Archimedes's force) is negligible to other forces.

Given:

- The strength of the gravitational field is $g = 10\,m.s^{-2}$;

- $m = 2,5.10^{-2}\ kg$.

0,5 **1-** By applying Newton's second law on the ball, show that the differential equation verified by the velocity v of the center inertia G is $\frac{dv}{dt} + \frac{k}{m}v = g$.

0,25 **2-** Find out the expression of the terminal velocity v_l of G in terms of g, m and k.

0,25 **3-** The curve in figure 2 represents the evolution of the velocity v of the center of inertia G of the ball.

Determine graphically the value of v_ℓ .

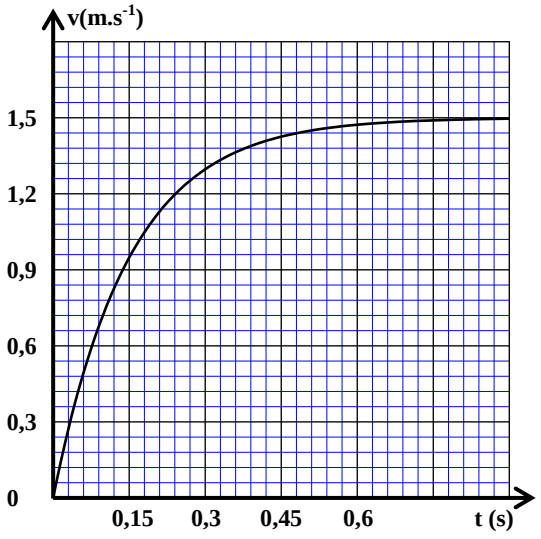


Figure 2

0,5 **4-** Verify, in the international units, that the differential equation of the motion of G is written as:

$$\frac{dv}{dt} = 10 - 6,67\,v$$

5- By using Euler's method and the data of the following table, calculate:

0,5 **5.1.** the acceleration a_1 at the instant t_1.

0,5 **5.2.** the velocity v_3 at the instant t_3 knowing that the step of calculating is $\Delta t = 0,015s$.

t	v (m.s^{-1})	a (m.s^{-2})
/	/	/
t_1	0,150	$a_1 = ...$
t_2	0,285	8,10
t_3	$v_3 = ...$	/