الامتحان الوطني الموحد للبكالوريا

المسالك الدولية

الدورة العادية 2021

- 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	3h
الشعبة أو المسلك	شعبة العلوم التجريبية مسلك علوم الحياة والأرض (خيار أنجليزية)	المعامل	5

- **The use of programmable scientific calculator is not 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)	• **Temporal monitoring of evolution of a chemical system** • **Determination of acidity constant of an Acid/Base couple**	**7 points**
Physics (13 points)	**Exercise 1: Propagation of waves on the surface of water**	**3,5 points**
	Exercise 2: Nuclear medicine	**3 points**
	Exercise 3: Discharge of a capacitor trough different dipoles	**6,5 points**

scale | **Subject**

Chemistry (7 points)

Part 1 and part 2 are independents

Redox or acid-base chemical transformations permit to know the effect of some solutions on metals, monitor the time evolution of a chemical system, and to study acid or base aqueous solutions.

This exercise aims at:

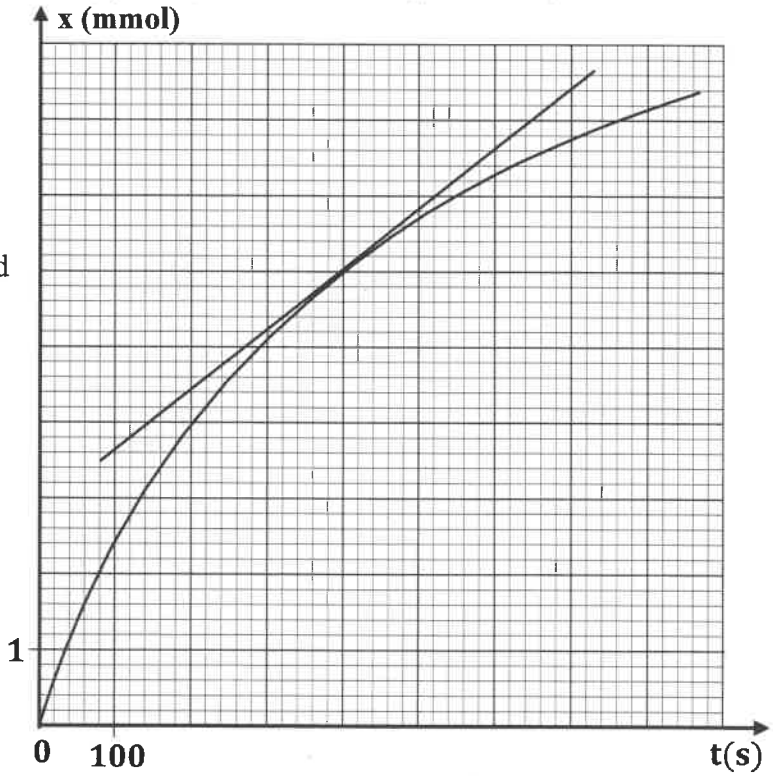
- **Temporal monitoring of evolution of a chemical system;**
- **Determination of acidity constant of an Acid/Base couple.**

Part 1: Temporal monitoring of evolution of a chemical system

We realise an experiment by introducing, at an instant $t_0 = 0$, a mass of zinc powder of value $m(Zn) = 1,0\ g$ in a round-bottom flask containing a volume $V = 40\ mL$ of an aqueous solution (S) of hydrochloride acid $H_3O^+_{(aq)} + Cl^-_{(aq)}$ of molar concentration $C_A = 0,5\ mol.L^{-1}$. The ions $H_3O^+_{(aq)}$ react with zinc $Zn_{(s)}$ according to the chemical equation: $2H_3O^+_{(aq)} + Zn_{(s)} \rightarrow H_{2(g)} + Zn^{2+}_{(aq)} + 2H_2O_{(l)}$.

Measuring the volume of hydrogen produced permit to monitor the evolution of the advancement x of the reaction and to draw the graph $x = f(t)$.

Data: $M(Zn) = 65,4\ g.mol^{-1}$



0,5 **1.** Calculate the amount of matter $n_0(Zn)$ and $n_0(H_3O^+)$, present initially in the reactional mixture.

0,5 **2.** Recopy, on your paper, the advancement table of the chemical reaction and complete it.

Chemical equation		$2H_3O^+_{(aq)}$ + $Zn_{(s)}$ → $H_{2(g)}$ + $Zn^{2+}_{(aq)}$ + $2H_2O_{(l)}$				
State of the system	Advancement (mol)	Amount of matter (mol)				
Initial state	$x = 0$					Excess
Intermediary state	x					Excess
Final state	x_f					Excess

0,5 **3.** Identify the limiting reactant. Justify

1 **4.** Determine graphically:

a. The value of half-life of reaction $t_{1/2}$.

b. The value of the volumetric rate of reaction, in unit $(mol.L^{-1}.s^{-1})$, at the instant $t = 400\ s$, knowing that the volume of the mixture is $V = 40\ mL$.

0,25 **5.** Interpret qualitatively the variation of the volumetric rate of reaction.

6. To accelerate the previous reaction, we restart the experiment using the same mass of zinc $m(Zn) = 1,0\ g$ and a volume $V = 40\ mL$ of a solution (S') of hydrochloride acid of molar concentration $C_A' = 1\ mol.L^{-1}$.

0,25 **6.1.** Give the kinematic factor which is the origin of the acceleration of this reaction.

0,5 **6.2.** The half-life $t_{1/2}$ of reaction, will increase or decrease? Justify.

Part 2: Determination of acidity constant of an Acid/Base couple

We consider an aqueous solution of propanoic acid $C_2H_5CO_2H$ of volume V, and molar concentration $C = 2.10^{-3}\ mol.L^{-1}$ and $pH = 3,79$ at $25°C$.

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

0,5 **2.** Calculate the value of the final progress rate τ of the reaction. Deduce.

0,75 **3.** Prove that the expression of acidity constant K_{A1} of the couple $(C_2H_5CO_2H_{(aq)} / C_2H_5CO_{2(aq)}^-)$ is written as: $K_{A1} = \dfrac{10^{-2.pH}}{C - 10^{-pH}}$. Verify that $K_{A1} = 1,43.10^{-5}$.

0,5 **4.** Represent the predominance diagram of the two species of the couple $(C_2H_5CO_2H_{(aq)} / C_2H_5CO_{2(aq)}^-)$ present on the studied solution.

5. Consider benzoic acid of formula $C_6H_5CO_2H$. We note K_{A2} the acidity constant of the couple $(C_6H_5CO_2H_{(aq)} / C_6H_5CO_{2(aq)}^-)$. To determine the value of K_{A2}, we mix the same volume of the solution of propanoic acid and a solution of sodium benzoate $C_6H_5CO_{2(aq)}^- + Na_{(aq)}^+$. The two solutions have the same molar concentration.

0,5 **5.1.** Write the chemical equation of reaction occurring between propanoic acid $C_2H_5CO_2H_{(aq)}$ and benzoate ions $C_6H_5CO_{2(aq)}^-$.

0,5 **5.2.** Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

The expression of equilibrium constant K associated with the chemical equation of this reaction is:

A	$K = \dfrac{K_{A2}}{K_{A1}}$	**B**	$K = K_{A1}.K_{A2}$	**C**	$K = \dfrac{K_{A1}}{K_{A2}}$	**D**	$K = \dfrac{1}{K_{A1}.K_{A2}}$

0,25 **5.3.** Calculate the value of K_{A2}, knowing that $K = 0,23$.

Physics (13 points)

Exercise 1 (3,5 points): Propagation of waves on the surface of water

The progressive perturbations created on the surface of water are mechanical waves. According to the experimental conditions, their propagation generates different phenomena. The study of these phenomena can provide information on this propagation and determine some characteristics.

This exercise aims at the study of the propagation of waves on the surface of water in two different situations.

Using a vibrator of adjustable frequency, we create at an instant $t_0 = 0$ at a point S of the surface of water of a wave tank, progressive sinusoidal waves. These waves propagate without reflexion or attenuation.

We adjust the frequency of the vibrator on $N = 50\ Hz$.

The document of Figure (1) represents the aspect of the surface of water at a given instant.

Data: $d = 15\,mm$

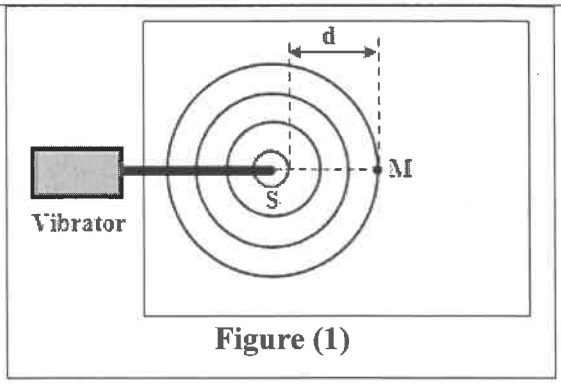


Figure (1)

0,5 **1.** Define the progressive mechanic wave.

2. Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

0,25 **2.1.** The value of the wavelength λ of the propagating wave on the surface of water is:

A	$\lambda = 15\,mm$	**B**	$\lambda = 7,5\,mm$	**C**	$\lambda = 5\,mm$	**D**	$\lambda = 1,5\,mm$

0,5 **2.2.** The value of velocity v of propagation of the wave on the surface of water is:

A	$v = 0,75\,m.s^{-1}$	**B**	$v = 0,35\,m.s^{-1}$	**C**	$v = 0,25\,m.s^{-1}$	**D**	$v = 0,15\,m.s^{-1}$

0,5 **2.3.** Consider a point M on the surface of water, where $SM = 17,5\,mm$. The elongation $y_M(t)$ of the point M in terms of the elongation $y_S(t)$ of the origin is written:

A	$y_M(t) = y_S(t - 0,07)$	**B**	$y_M(t) = y_S(t - 0,35)$	**C**	$y_M(t) = y_S(t + 0,07)$	**D**	$y_M(t) = y_S(t + 0,35)$

0,75 **3.** We adjust the vibrator on the value $N' = 100\,Hz$, the wavelength of the wave becomes $\lambda' = 3\,mm$.

Is water a dispersive medium? Justify.

4. We readjust the value of frequency on $N = 50\,Hz$, and we put on the surface of the tank an obstacle containing an opening of width $a = 4,5\,mm$ (Figure (2)).

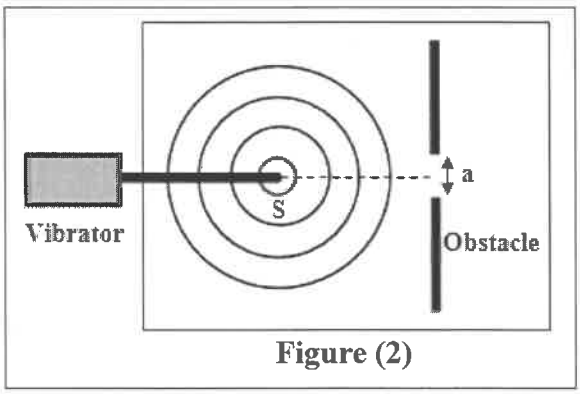


Figure (2)

0,5 **4.1.** Name the produced phenomenon. Justify.

0,5 **4.2.** Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

The values of the wavelength and velocity of propagation of the waves on the surface of water when the wave passes through the opening are:

A	$\lambda = 3\,mm$ $v = 0,15\,m.s^{-1}$	**B**	$\lambda = 15\,mm$ $v = 0,10\,m.s^{-1}$	**C**	$\lambda = 5\,mm$ $v = 0,20\,m.s^{-1}$	**D**	$\lambda = 5\,mm$ $v = 0,25\,m.s^{-1}$

Exercise 2 (3points): Nuclear medicine

Scintigraphy is a technique used to explore the human body that can diagnose diseases. It consists of injecting a radioactive tracer product which binds temporarily to certain tissues or organs. In the case of bone scintigraphy, the tracer product is composed of the diphosphonate coupled to metastable technetium $^{99}Tc^*$ which is γ ray emitter.

This exercise aims at the study of utilisation of technetium in medicine.

Data:

Particle or nucleus	Electron	$^{99}_{42}Mo$	$^{99}_{43}Tc$
Mass in u	$5,486.10^{-4}$	98,884	98,882
$1\,u = 931,5\,MeV.c^{-2}$			

1.Production of technetium $^{99}Tc^*$

Inside the generators of (Molybdenum/Technetium), molybdenum $^{99}_{42}Mo$ is disintegrated according to the equation: $^{99}_{42}Mo \rightarrow {}^{99}_{43}Tc^* + {}^{A}_{Z}X$

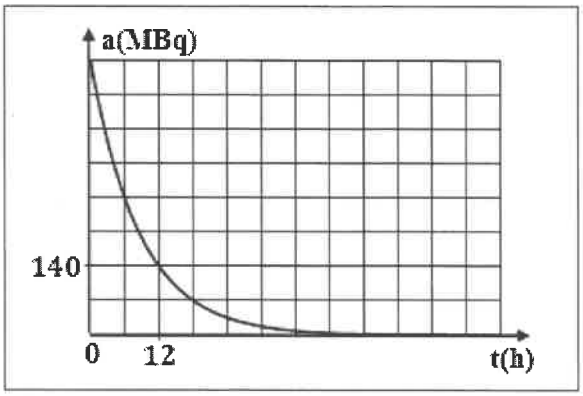
0,5 **1.1.** Precise, by justification, the type of this disintegration.

0,5 **1.2.** Determine, in unit MeV, the value of released energy $E_{released} = |\Delta E|$, by the disintegration of a nucleus $^{99}_{42}Mo$.

2. Bone scintigraphy using technetium

To undergo a bone scintigraphy, a nurse injects, at an instant $t_0 = 0$, to a patient a dose of technetium $^{99}Tc^*$ product.

Figure on the right represents the evolution of the activity of a dose during the disintegration of technetium $^{99}Tc^*$.



0,5 **2.1.** Determine, graphically, the value of half-life $t_{1/2}$ of technetium $^{99}Tc^*$.

0,5 **2.2.** Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

The value of radioactivity constant λ of $^{99}Tc^*$ is:

A	$\lambda = 0,1155\ h^{-1}$	**B**	$\lambda = 1,453.10^{-2}\ h^{-1}$	**C**	$\lambda = 1,521.10^{-2}\ h^{-1}$	**D**	$\lambda = 2,253.10^{-2}\ h^{-1}$

0,5 **2.3.** An exam is realised three (3) hours after the injection of the dose.

Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

The number N of nuclei of technetium $^{99}Tc^*$ at the moment of the exam is:

A	$N = 1,23.10^{13}$	**B**	$N = 4,32.10^{13}$	**C**	$N = 5,25.10^{14}$	**D**	$N = 7,12.10^{14}$

0,5 **2.4.** Is it possible to realise the same exam for patient 48 hours after the injection of the dose? Justify.

Exercise 3 (6,5 points): Discharge of a capacitor through different dipoles

Coil and capacitor are two components of major importance in the electric circuits. Functioning of such circuits depends on the connection of this components, which produce different phenomenon. We can thus proceed to the study of the charge and discharge of a capacitor, establishment and interruption of electric current, free electric oscillations and energetic exchange on the circuit. This exercise aims at the study of the discharge of a capacitor through an ohmic conductor, and then through a coil.

We consider the electric circuit on figure (1), composed of:

-an ideal generator of electromotive force $E = 6\ V$;

-a capacitor of capacity C initially not charged;

-a switch K of double position;

-a dipole D.

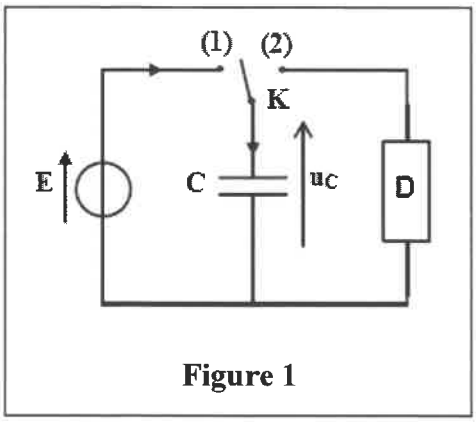


Figure 1

0,5 **1.** At the instant $t_0 = 0$, we place the switch on position (1). The maximal charge of the capacitor is $Q_0 = 3\,\mu C$. Prove that $C = 0,5\,\mu F$.

2. We realise three experiments ①, ② and ③ using the dipole D which may be:

-an ohmic conductor of resistance R (experiment ①);

-a coil $b_1(L_1\ ;\ r_1 = 0)$ (experiment ②);

-a coil $b_2(L_2\ ;\ r_2 = 10\,\Omega)$ (experiment ③).

For every experiment, we charge totally the capacitor, then we discharge it by switching to position (2) at $t_0 = 0$.

Using an adequate acquisition system, we obtain the variations of the voltage $u_C(t)$ on the terminals of the capacitor in the case of the three experiments (Figure (2)).

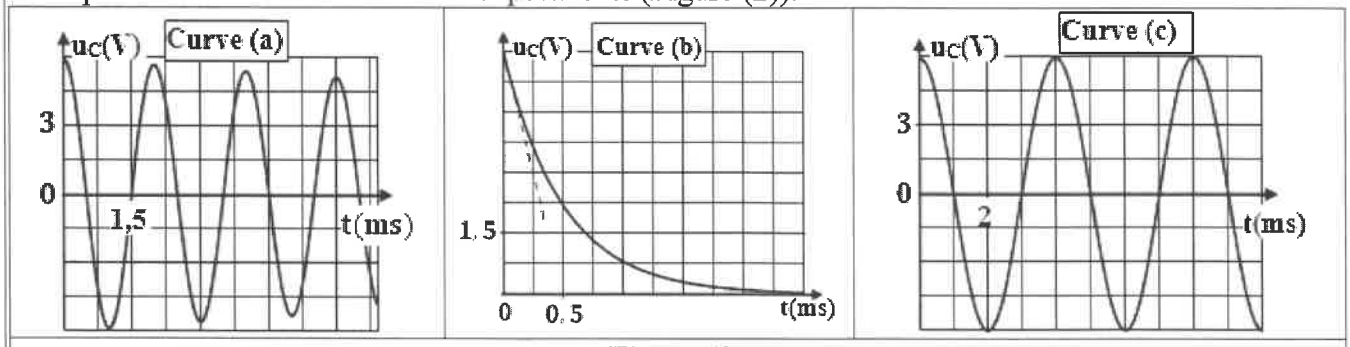


Figure (2)

0,5 **2.1.** Associate every curve to the corresponding experiment. Justify.

0,5 **2.2.** In the case of the experiment ①, determine the value of the time constant τ of the circuit. Deduce the value of R.

1 **2.3.** In the case of the experiment ③:

a. Give the name of the oscillation regime occurred.

b. Explain, energetically, the shape of the obtained curve.

c. Determine the value of the pseudo-period T.

3. In the case of the experiment ②:

0,25 **3.1.** Determine the value of the period T_0.

0,5 **3.2.** Determine the value of L_1.

0,5 **3.3.** Prove that the differential equation verified by the charge $q(t)$ of the capacitor is written as:

$$\frac{d^2q}{dt^2}+\frac{1}{L_1.C}.q=0 .$$

1,25 **3.4.** The solution of the differential equation is: $q(t)=Q_m.\cos(\frac{2\pi}{T_0}.t+\varphi)$

Copy on your answer sheet the number of the question and write the letter corresponding to the right option (A, B, C or D).

a. The numerical expression of the charge q in coulomb is:

A	$q(t)=3.10^{-6}.\cos(500.\pi.t)$	**B**	$q(t)=0,5.10^{-6}.\cos(500.\pi.t)$
C	$q(t)=6.10^{-6}.\cos(500.\pi.t+\frac{\pi}{2})$	**D**	$q(t)=3.10^{-6}.\cos(500.\pi.t+\pi)$

b. The value of the maximal intensity I_{max} of the electric current passing through the circuit is:

A	$I_{max}=7,33\,mA$	**B**	$I_{max}=6,85\,mA$	**C**	$I_{max}=5,22\,mA$	**D**	$I_{max}=4,71\,mA$

0,5 **3.5.** The total energy $\mathscr{E}$ of the circuit is conserved. Explain why?

0,5 **3.6.** Calculate the value of the total energy $\mathscr{E}$ of the circuit.

0,5 **3.7.** Calculate the absolute value $|q|$ of the charge $q(t)$ of the capacitor when the electric energy $\mathscr{E}_e$ stored in the capacitor is equal to the magnetic energy $\mathscr{E}_m$ stored on the coil.