الصفحة 1 / 8	الامتحان الوطني الموحد للبكالوريا المسالك الدولية الدورة العادية 2022 – الموضوع –	المملكة المغربية وزارة التربية الوطنية والتعليم الأولي والرياضة المركز الوطني للتقويم والامتحانات
*I	SSSSSSSSSSSSSSSSSSSS-SS / NS 28E	

3h	مدة الإنجاز	الفيزياء والكيمياء	المادة
7	المعامل	شعبة العلوم التجريبية: مسلك العلوم الفيزيائية - خيار إنجليزية	الشعبة أو المسلك

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 1 (7 points):

- Chromium-electroplating a steel plate by electrolysis
- Study of some properties of an aqueous solution of the propanoic acid

Exercise 2 (3,5 points):

- Sound waves
- Disintegration of the iodine-131

Exercise 3 (4,5points):

- Response of the RC dipole to a step voltage
- Free oscillations in a RLC series circuit

Exercise 4 (5 points):

- Study of the fall of a ball in a viscous liquid
- Study of the motion of an artificial satellite

Marking scale

EXERCISE 1 (7 points)

Part 1 and part 2 are independent

Part 1 : Chromium-electroplating a steel plate by electrolysis

The electrolysis is the process of converting electric energy into chemical energy.
Electroplating objects with a thin layer of a metal and protecting them against the corrosion are some uses of the electrolysis.
In this part, we suggest the study of the chromium-electroplating a steel plate by electrolysis.
Given :

- Redox pairs involved are : $Cr^{3+}_{(aq)} / Cr_{(s)}$ and $O_{2(g)} / H_2O_{(\ell)}$
- $1F = 96500\,C.mol^{-1}$
- Molar mass of the chromium : $M(Cr) = 52\,g.mol^{-1}$

To perform this electrolysis, we immerse totally a steel plate in an aqueous solution of the chromium (III) chloride $Cr^{3+}_{(aq)} + 3Cl^{-}_{(aq)}$ and we connect it to one pole of a generator G. the other pole of the generator is connected to a graphite electrode (figure1). We switch on the circuit, an electric current of constant intensity $I = 2\,A$ flows in the circuit. We observe that the oxygen $O_{2(g)}$ is released at the graphite electrode and a uniform layer of the chromium is deposited on the steel plate.

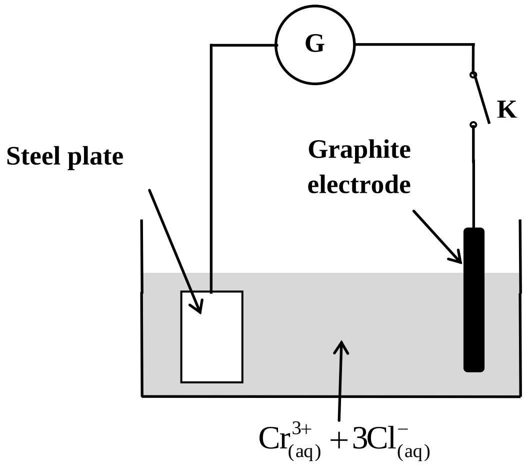

Figure1

0,5 **1.** Identify which electrode is the cathode. Justify your answer.
2. Copy the number of the question and choose the correct answer from the proposals.
0,5 **2.1.**The equation for the reaction occurring at the graphite electrode is written as :

A	$2H_2O_{(\ell)} \rightleftarrows O_{2(g)} + 4H^{+}_{(aq)} + 4e^{-}$	**B**	$Cr^{3+}_{(aq)} + 3e^{-} \rightleftarrows Cr_{(s)}$
C	$2O^{2-}_{(aq)} \rightleftarrows O_{2(g)} + 4e^{-}$	**D**	$2H_2O_{(\ell)} \rightleftarrows O_{2(g)} + 2H_{2(g)}$

0,5 **2.2.** The equation for the reaction occurring at the steel plate is written as :

A	$2H_2O_{(\ell)} \rightleftarrows O_{2(g)} + 4H^{+}_{(aq)} + 4e^{-}$	**B**	$Cr^{3+}_{(aq)} + 3e^{-} \rightleftarrows Cr_{(s)}$
C	$Cr^{2+}_{(aq)} + 2e^{-} \rightleftarrows Cr_{(s)}$	**D**	$2H_2O_{(\ell)} \rightleftarrows O_{2(g)} + 2H_{2(g)}$

0,75 **3**. The duration of this electrolysis is $\Delta t = 2\,h$. Determine the mass m(Cr) of chromium deposited on the steel plate.

Part 2 : Study of some properties of an aqueous solution of the propanoic acid

The propanoic acid of formula C_2H_5-COOH *can be used as a food conservator and in the manufacture of the anti-inflammatory drugs. The propanoic acid is also involved in many organic synthesises.*
The objective of this part is to study some properties of an aqueous solution of the propanoic acid.

1. Aqueous solution of the propanoic acid

We prepare an aqueous solution S_a of the propanoic acid of concentration $C_a = 5.10^{-2} mol.L^{-1}$.

The measurement of the pH of the solution S_a gives $pH = 3,1$.

0,5 **1.1.** Write the equation for the reaction between the propanoic acid and water.

0,75 **1.2.** Calculate the final progress rate τ of this reaction. What can you deduce?

0,75 **1.3.** Express the reaction quotient at equilibrium $Q_{r,eq}$ associated to the equation of the previous reaction in terms of C_a and $\left[H_3O^+_{(aq)}\right]_{eq}$. Calculate its value.

0,5 **1.4.** Deduce the value of pK_A of the pair $C_2H_5COOH_{(aq)} / C_2H_5COO^-_{(aq)}$.

2- Titration of the solution of the propanoic acid

To verify the value of the concentration C_a of the solution S_a, we perform the pH-metric titration of a volume V_a= 20mL of the solution S_a by an aqueous solution S_b of the sodium hydroxide $Na^+_{(aq)} + HO^-_{(aq)}$ of molar concentration $C_b = 5.10^{-2} mol.L^{-1}$.

In figure 2, we represent the curve of the pH variations of the reaction mixture as a function of the volume V_b added from the solution S_b and the curve $\frac{dpH}{dV_b} = f(V_b)$.

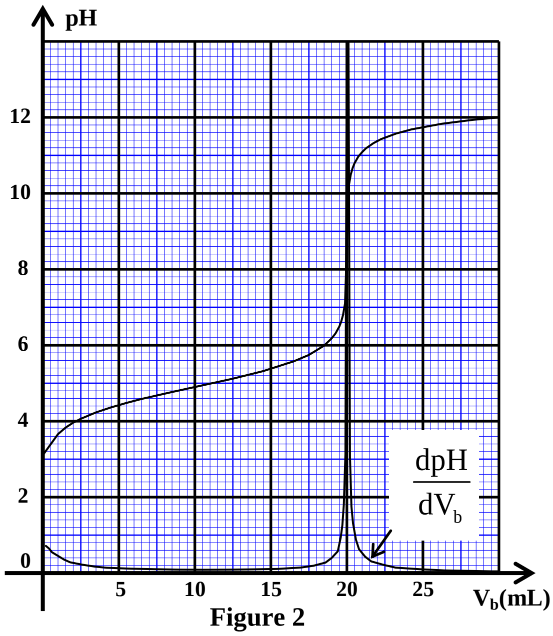

Figure 2

0,5 **2.1.** Write the equation for the reaction of titration.

0,25 **2.2.** Determine graphically the volume V_{bE} of the solution S_b added at the equivalence.

0,5 **2.3.** Verify the value of the concentration C_a.

0,5 **2.4.** We prepare the solution S_a by diluting 10 times an aqueous solution S_0 of the propanoic acid. Determine the mass m of the propanoic acid dissolved in one litre of the solution S_0.

Given : The molar mass of the propanoic acid is $M = 74 g.mol^{-1}$.

0,5 **2.5.** For a volume $V_b = 5 mL$ of the solution S_b added, determine the percentage of the acid of the pair $C_2H_5COOH_{(aq)} / C_2H_5COO^-_{(aq)}$ in the reaction mixture.

EXERCISE 2 (3,5 points)

Part 1 and part 2 are independent

Part 1: Propagation of sound waves in the air

To determine the wave speed of sound waves in the air, we perform the experimental set-up in figure 1. This set-up is consisted of a transmitter E and of a receiver R of sound waves distance $L = 85 cm$ from each other. E emits a sound wave, it propagates in the air, and then R receives it.

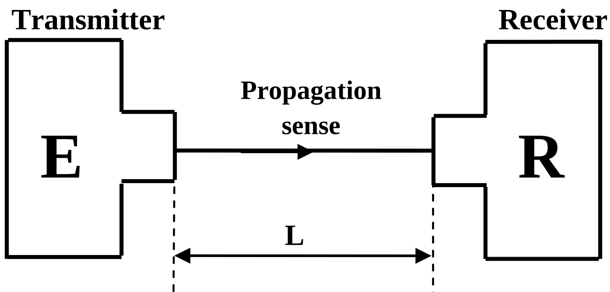

Figure 1

A datalogger is used to visualise both the emitted signal (a) and the received signal (b) (figure 2).

1. Copy the number of the question and answer by true or false.

0,25 **1.1.** The sound wave is a transverse wave.

0,25 **1.2.** The sound wave does not propagate in vacuum.

0,25 **2.** Determine the duration Δt taken to reach the receiver R.

0,5 **3.** Calculate the wave speed v of the sound waves in the air.

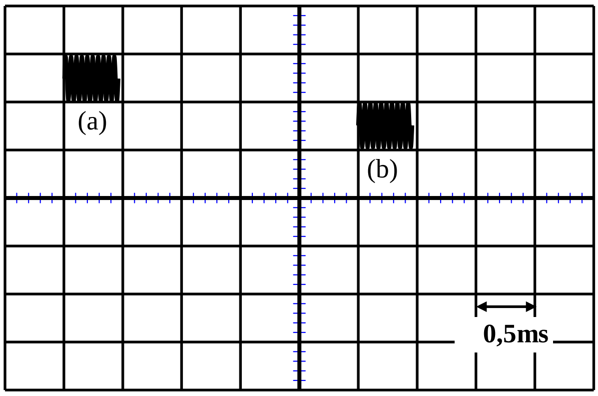

Figure 2

Part 2 : Disintegration of the iodine-131

The iodine-131 $({}^{131}_{53}I)$ *is radioactive of* β^- *type.*

The iodine can be used in small doses for medical purposes such as the diagnostic of the thyroid gland dysfunction and the treatment of some diseases relating to this gland.

The disintegration of the iodine-131 gives a nucleus ${}^{A}_{Z}X$.

In this part, we suggest studying the disintegration of the iodine-131.

Given :

Element	Tellurium		Xenon		Cesium	
Some isotopes of the element	${}^{131}_{52}Te$	${}^{132}_{52}Te$	${}^{130}_{54}Xe$	${}^{131}_{54}Xe$	${}^{127}_{55}Cs$	${}^{132}_{55}Cs$

- Mass of the iodine-131 nucleus: $m({}^{131}_{53}I) = 130,906125\ u$;
- Mass of the nucleus ${}^{A}_{Z}X$: $m({}^{A}_{Z}X) = 130,905082 u$;
- Mass of the particle β^- : $m(\beta^-) = 5,48580.10^{-4} u$;
- Atomic mass unit : $1u = 931,5 MeV.c^{-2}$.

0,5 **1.** Write the equation for the disintegration of the iodine-131 by identifying ${}^{A}_{Z}X$ the produced nucleus.

0,5 **2.** Calculate, in MeV, the released energy E_{pro} produced by the disintegration of the iodine-131 nucleus.

3. At an instant taken as origin of time t = 0, a patient gets a dose of the iodine-131 solution of activity a_0.

The curve in figure 3 represents the variations of the activity a(t) of this dose as a function of time.

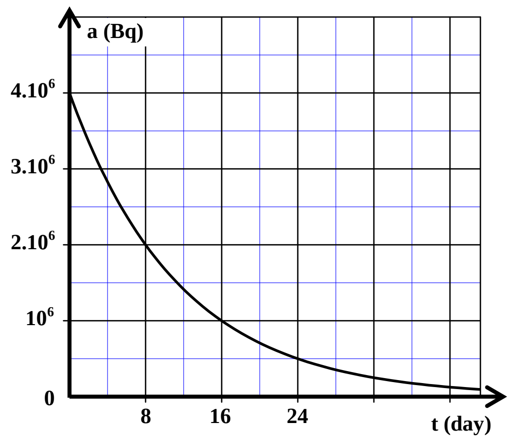

Figure 3

0,25 **3.1.** Determine graphically the half-life $t_{1/2}$ of the iodine-131.

0,5 **3.2.** Calculate N_0 the number of the iodine-131 nuclei present in the dose at t = 0.

0,5 **3.3.** By using the radioactive decay law, determine, in days, the instant t_1 when 95% of the iodine-131 nuclei are disintegrated.

EXERCISE 3 (4,5 points)

This exercise aims at :
- determining the capacitance of a capacitor ;
- determining the inductance of an inductor ;
- doing the energetic study of the RLC series circuit.

We perform the electric set-up in figure 1. This set-up is consisted of the following components:

- an ideal power supply of voltage of electromotive force E;
- a capacitor of capacitance C initially discharged;
- an inductor of inductance L and of resistance r;
- a resistor of resistance R;
- a double switch K.

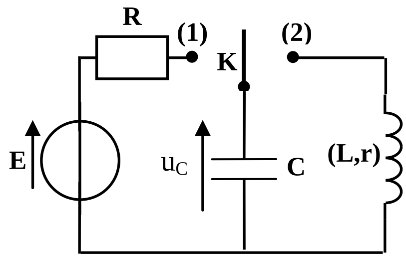

Figure 1

1. Response of the RC dipole to a step of voltage

At an instant taken as origin of time $t = 0$, we put the switch K at position (1).The curves (C_1) and (C_2) in figure 2 represent the evolution of the voltage $u_C(t)$ between terminals of the capacitor and the evolution of the intensity i(t) of the electric current which flows in the circuit.
(T) is the tangent of the curve (C_1) at the point of time $t = 0$.

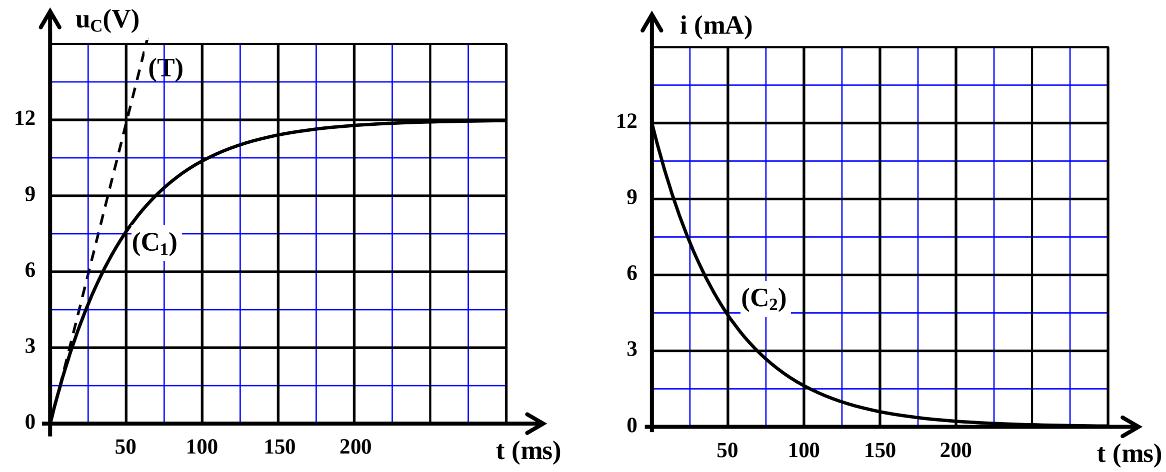

Figure 2

0,25 **1.1.** Show that the differential equation of the voltage $u_C(t)$ is written as : $\frac{du_C}{dt} + \frac{1}{R.C}u_C = \frac{E}{R.C}$

1.2. The solution of this differential equation is : $u_C(t) = E(1 - e^{\frac{-t}{RC}})$.

0,5 **1.2.1.** Find out the expression of the electric current intensity i(t) in terms of E, R, C and t.

0,5 **1.2.2.** By exploiting the curves in figure 2, determine the value of R.

0,25 **1.2.3.** Show that the capacitance C of the capacitor is : $C = 50\mu F$.

2. Free oscillations in a RLC series circuit

When the capacitor of capacitance $C = 50\mu F$ is fully charged, we placed the switch K at position (2) at an instant taken as a new origin of time $t = 0$. This capacitor discharges through the inductor of inductance L and of resistance r (figure 1).

2.1. First case :

In this case, we suppose that the resistance of the inductor is negligible.

0,25 **2.1.1.** Show that the differential equation of the voltage $u_C(t)$ is written as : $\frac{d^2u_C}{dt^2} + \frac{1}{LC}.u_C = 0$.

0,5 **2.1.2.** Choose from the following curves (C_1) and (C_2) and (C_3) in figure 3 (page 6/8), which one represents the evolution of the voltage $u_C(t)$. Justify your answer.

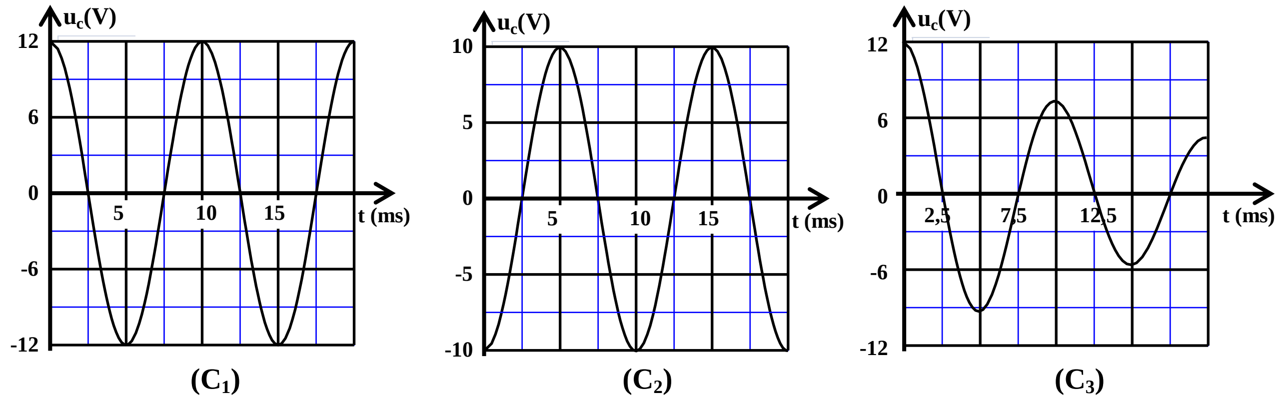

Figure 3

2.1.3. The solution of the previous differential equation is : $u_c(t) = U_0 \cos(\frac{2\pi}{T_0} t)$ where U_0 is the maximum value of the voltage and T_0 is the natural period of the oscillations.

0,5 **a-** Find out the expression of T_0 in terms of L and C.

0,5 **b-** Show that the value of the inductance is : $L = 0,05\,H$. (take $\pi^2 = 10$).

2.2. Second case :

In fact, the resistance of the inductor is not negligible. In this case and by using a datalogger, we visualise the curves of the evolution of the voltage $u_C(t)$ between terminals of the capacitor and the evolution of the intensity of the electric current $i(t)$ which flows through the circuit (figure 4).

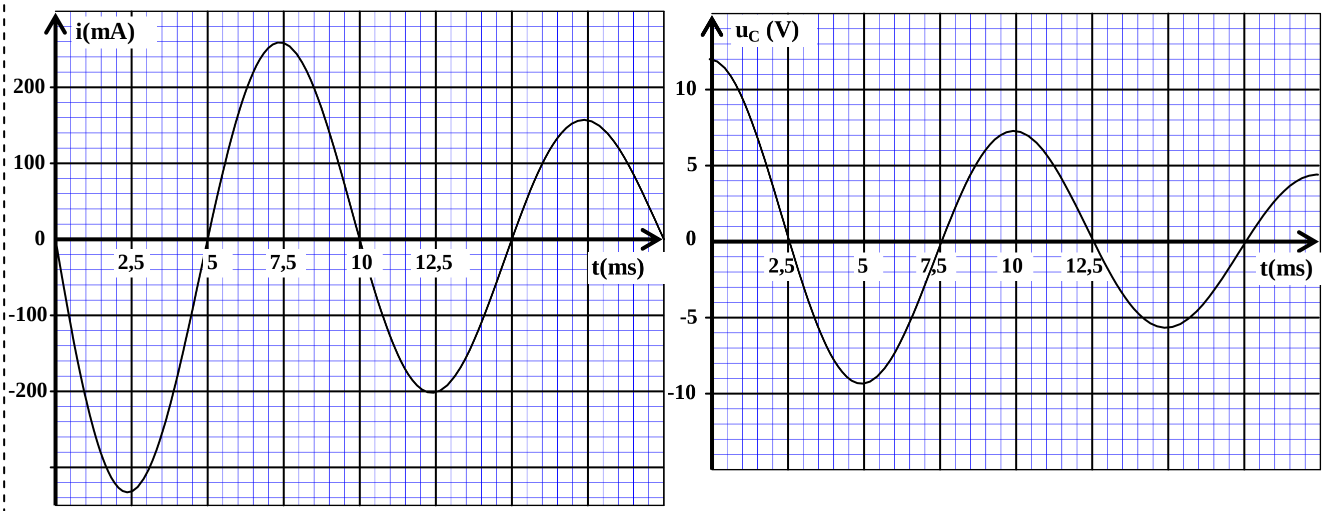

Figure 4

0,5 **2.2.1.** Write the expression of the total energy E_t of the circuit in terms of C, $u_C(t)$, L and i(t).

0,75 **2.2.2.** By exploiting the curves in figure 4, calculate the dissipated energy ΔE in the circuit between the instants $t_0 = 0$ and $t_1 = 9\,ms$.

EXERCISE 4 (5 points)

Part 1 and part 2 are independent

Part 1: Study of the fall of a ball in a viscous liquid

In this part, we suggest determining the density ρ_r of the ricin oil.

We get off without initial velocity a homogenous steel ball in a cylinder filled with the ricin oil. This ball is of mass m and of density ρ_a .

We study the motion of the center of inertia G of the ball in the coordinate system $(O,\vec{k})$ linked to an Earth frame of reference assumed Galilean (figure 1).

Over this vertical falling in the liquid, the ball obeys three forces:

- its weight $\vec{P}$.
- the upthrust (Archimedes' force) $\vec{F_a}$ is of vertical direction, of upward sense and of magnitude $F_a = \rho_r.V.g$ where V is the volume of the ball and g is the gravitational acceleration.
- the viscous frictional force which is modeled with the vector $\vec{F} = -k.\vec{v}$ where k is a positive constant and $\vec{v}$ is the velocity of G at an instant t.

A datalogger permits plotting the curve in figure 2 which represents the evolution of the speed v(t).

(T) is the tangent of the curve at the point of time t=0.

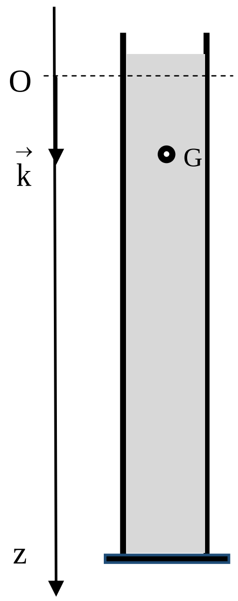

Figure1

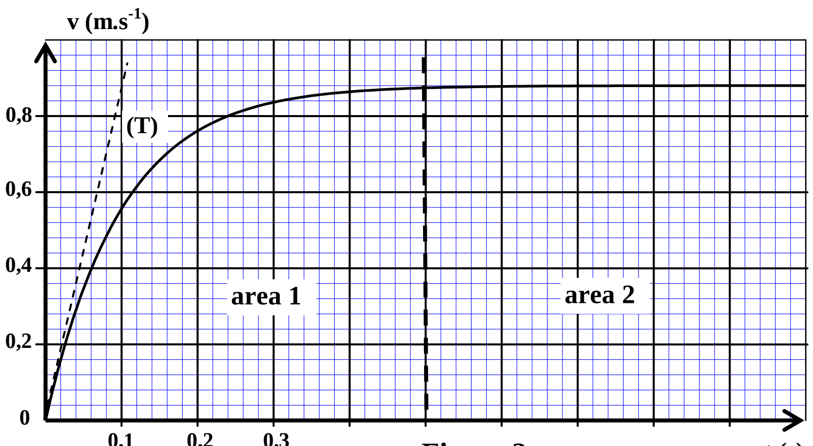

Figure 2

Given : m =10 g ; $\rho_a = 7{,}8\,g.cm^{-3}$; g =10 m.s^{-2} .

0,5 **1**. The curve in figure 2 includes two areas. Determine for each area, the corresponding state.

0,75 **2.** By applying Newton's 2nd law, show that the differential equation of the motion of G is written as : $\frac{dv}{dt} + \frac{1}{\tau}.v = g(1 - \frac{\rho_r}{\rho_a})$ where τ is the characteristic time of the motion that to be expressed in terms of m and k.

3. Determine graphically,

0,5 **3.1.** the value of τ then deduce, in SI units, the value of k.

0,25 **3.2.** the value of the terminal speed V_ℓ .

0,75 **4**. Find the expression of the density ρ_r of the ricin oil in terms of τ , g , ρ_a and V_ℓ . Calculate its value.

Part 2: Study of the motion of an artificial satellite

Many artificial satellites orbit the Earth for a variety of purposes such as weather forecasting, telecommunication, scientific researches and borders observation…

The objective of this part is to study some physical quantities characterising the motion of an artificial satellite around the Earth.

We study the motion of an artificial satellite S of mass m_s in a geocentric frame of reference assumed Galilean.

We assume that the Earth presents a uniform spherical mass.

All other forces are negligible to the universal attraction force exerted by the Earth on this satellite and its dimensions are negligible to the distance of the center of the Earth.

Given :

- Masse of the Earth: $M_E = 5{,}97.10^{24}$kg;
- Radius of the Earth : $R_E = 6380$ km ;
- Gravitational constant : $G = 6{,}67.10^{-11}\,N.m^2.kg^{-2}$.

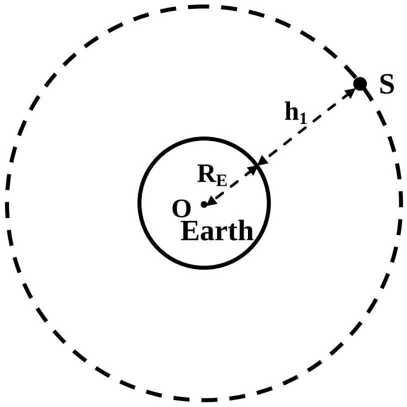

Figure 3

1. This satellite is placed at a circular orbit of center O and of radius $r = R_E + h_1$ where $h_1 = 1000$ km (figure 3).

0,5 **1.1.** Choose the correct answer from the proposals.

The expression of the magnitude of the universal attraction force exerted by the Earth on the satellite is :

A	$F_{E/S} = G\dfrac{M_E.m_S}{h_1^2}$	**B**	$F_{E/S} = G\dfrac{M_E.m_S}{(R_E+h_1)^2}$	**C**	$F_{E/S} = G\dfrac{M_E.m_S}{R_E^2}$	**D**	$F_{E/S} = G\dfrac{(M_E.m_S)^2}{(R_E+h_1)^2}$

0,5 **1.2.** By applying the Newton's 2nd law, show that the expression of the speed v of the satellite is : $v = \sqrt{\dfrac{G.M_E}{R_E + h_1}}$.

0,5 **1.3.** Verify that the orbital period of the motion of the satellite around the Earth is $T_1 \approx 1{,}75\,h$.

0,75 **2.** The satellite S is placed at another circular orbit at an altitude h_2 of the surface of the Earth. The motion of the satellite is circular uniform of the orbital period $T_2 = 24\,h$.

By using the Kepler's 3rd law, determine the altitude h_2 of this satellite.

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية
الدورة العادية 2022

المملكة المغربية
وزارة التربية الوطنية
والتعليم الأولي والرياضة
المركز الوطني للتقويم والامتحانات

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7	المعامل	3h	مدة الإنجاز	الفيزياء والكيمياء شعبة العلوم التجريبية: مسلك العلوم الفيزيائية - خيار إنجليزية	المادة الشعبة والمسلك

EXERCISE 1 (7 points)

	Question	Answers	Marking scale	Question reference in the framework
Part 1	1.	Cathode = steel plate Justification	0,25 0,25	- Recognise the anode electrode (oxidation) and the cathode electrode (reduction) using the flow of electric current imposed by an external voltage supply. - Write the half-equation that occurred in each electrode (use double arrows) and write the overall equation of the reaction during electrolysis (use one arrow). Establish the relationship between the amount of substance of chemical specie produced or consumed, the current intensity and the operating duration of electrolysis. Use this relationship to determine other quantities (quantity of charge, progress of the reaction, change of the mass, volume of a gas, etc.).
	2.1.	A	0,5	
	2.2.	B	0,5	
	3.	$m(Cr)=\dfrac{I.\Delta t.M(Cr)}{3.F}$ $m(Cr)\approx 2,59\,g$	0,5 0,25	
Part 2	1.1.	$C_2H_5COOH_{(aq)}+H_2O_{(\ell)}\rightleftarrows C_2H_5COO^-_{(aq)}+H_3O^+_{(aq)}$	0,5	- Write the equation of the acid-base reaction and identify the two pairs involved. Calculate the final progress of the reaction that occurs between an acid and water taking into consideration the value of both the concentration and this acid's pH aqueous solution; then, compare it with the maximum progress. - Define the final progress rate of a reaction, and determine it using experimental data. - Give and use the expression of the reaction quotient Q_r through the reaction equation. - Know that, the reaction quotient in equilibrium $Q_{r,eq}$, associated to the reaction equation of a chemical system, takes a value independent of concentrations, called equilibrium constant K. - Know the relationship $pK_A= -logK_A$. - Write the equation of titration reaction (use only one arrow) - Exploit the curve or the results of the titration. - Determine and exploit the point of equivalence.
	1.2.	$\tau\approx 1,6\%$ Limited reaction	0,5 0,25	
	1.3.	$Q_{r,eq}=\dfrac{[H_3O^+]^2_{eq}}{C_a-[H_3O^+]_{eq}}$ $Q_{r,eq}\approx 1,28.10^{-5}$	0,5 0,25	
	1.4.	$pK_A\approx 4,89$	0,5	
	2.1.	$C_2H_5COOH_{(aq)}+HO^-_{(aq)}\rightarrow C_2H_5COO^-_{(aq)}+H_2O_{(\ell)}$	0,5	
	2.2.	$V_{bE}=20\,mL$	0,25	
	2.3.	$C_a=\dfrac{C_b.V_{bE}}{V_a}$ $C_a=5.10^{-2}mol.L^{-1}$	0,25 0,25	
	2.4.	$m=10.C_a.V.M$ $m=37\,g$	0,25 0,25	
	2.5.	Method $\%(C_2H_5COOH)\approx 75\%$	0,25 0,25	

EXERCISE 2 (3,5 points)				
Question		**Answers**	**Marking scale**	**Question reference in the framework**
Part 1	**1.1.**	False	**0,25**	- Define a mechanical wave and its wave speed. - Define a transverse wave and a longitudinal wave. - Exploit the relationship between time delay, distance and wave speed. - Exploit experimental documents and data in order to determine: * time delay; * wave speed.
	1.2.	True	**0,25**	
	2.	$\Delta t = 2,5\,ms$	**0,25**	
	3.	Method $v = 340\,m.s^{-1}$	**0,25** **0,25**	
Part 2	**1.**	${}^{131}_{53}I \rightarrow {}^{A}_{Z}X + {}^{0}_{-1}e$ The produced nucleus is : ${}^{131}_{54}Xe$	**0,25** **0,25**	- Define the radioactivity α, β^+, β^- and the γ radiation - Write the equation of a nuclear reaction by applying the two conservation laws. - Calculate the energy released (produced) by a nuclear reaction: $E_{pro} = \lvert\Delta E\rvert$. - Recognize the type of radioactivity using the equation of a nuclear reaction. - Know and exploit the law of the radioactive decay, and exploit its curve. - Define the time constant τ and the half-life $t_{1/2}$. - Exploit the relationships between τ, λ and $t_{1/2}$.
	2.	Method $\lvert\Delta E\rvert \approx 0,46\,MeV$	**0,25** **0,25**	
	3.1.	$t_{1/2} = 8\,days$	**0,25**	
	3.2.	Method $N_0 \approx 4.10^{12}$	**0,25** **0,25**	
	3.3.	Method $t_1 \approx 34,58\,days$	**0,25** **0,25**	

EXERCISE 3 (4,5 points)

Question	Answers	Marking scale	Question reference in the framework
1.1.	Method	**0,25**	- Know and exploit the relationship $i=\frac{dq}{dt}$ for a capacitor in receiver convention. - Know and exploit the relationship q = C.u. - Know the capacitance of a capacitor, its unit F and their submultiples $\mu F, nF$ *and* pF . - Determine the capacitance of a capacitor graphically or by calculation. - Find out the differential equation and verify its solution when the RC dipole is submitted to a step voltage. - 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. - Recognize and represent the variation curves of $u_C(t)$ between the capacitor terminals and different physical quantities associated to it, and exploit them. - Know and exploit the time-constant expression. - Exploit experimental documents in order to: * recognize the observed voltages. *determine the time-constant and charge duration.
1.2.1	Method $i(t)=\frac{E}{R}.e^{-\frac{t}{RC}}$	**0,25** **0,25**	
1.2.2	Method $R=1k\Omega$	**0,25** **0,25**	
1.2.3	Method	**0,25**	
2.1.1	Method	**0,25**	- Recognize and represent the variation curves of the voltage between capacitor terminals in terms of time for the three states mentioned above; and exploit them. - Find out the differential equation for the voltage between the capacitor terminals or for its charge $q(t)$ in the negligible damping case and verify its solution. - Know and exploit the natural period expression. - Know and exploit the energetic diagrams. - Know and exploit the expression of the total energy in the circuit.
2.1.2	The curve is (C_1) Justification	**0,25** **0,25**	
2.1.3-a	Method $T_0=2\pi\sqrt{LC}$	**0,25** **0,25**	
2.1.3-b	Method	**0,5**	
2.2.1	$E_t=\frac{1}{2}C.u_C^2+\frac{1}{2}L.i^2$	**0,5**	
2.2.2.	Method $\Delta E=-2,21.10^{-3}J$	**0,5** **0,25**	

EXERCISE 4 (5 points)

	Question	Answers	Marking scale	Question reference in the framework
Part 1	**1.**	Area 1 : initial state Area 2 : Steady state	**0,25** **0,25**	- Know and exploit the two models of frictional fluids (viscous forces): $\vec{F}=-k.v.\vec{i}$ and $\vec{F}=-k.v^2.\vec{i}$ - Exploit the curve $v_G=f(t)$ to determine: * the terminal speed; * the characteristic time τ ; * the initial state and the steady state. - Apply Newton's second law to find out the differential equation of a solid's centre of inertia motion in frictional vertical fall.
	2.	Method $\tau=\frac{m}{k}$	**0,5** **0,25**	
	3.1.	$\tau=0,1s$ $k=0,1\ (SI)$	**0,25** **0,25**	
	3.2.	$v_\ell=0,88\,m.s^{-1}$	**0,25**	
	4.	$\rho_r=\rho_a(1-\frac{V_\ell}{g.\tau})$ $\rho_r\approx0,94\,g.cm^{-3}$	**0,5** **0,25**	
Part 2	**1.1.**	B	**0,5**	- Know the heliocentric and geocentric frames of reference. - Apply Kepler's three laws in the case of a circular trajectory. - Know the universal gravitation law in its vectorial form. - Know that the gravitational force applied on the centre of mass of a satellite or of a planet is centripetal. - Apply the Newton's second law to the centre of mass of a satellite or of a planet to determine the type of motion or one of parameters that characterizes the motion.
	1.2.	Method	**0,5**	
	1.3.	Method	**0,5**	
	2.	Method $h_2\approx35903,6\,km$	**0,5** **0,25**	