الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2018
-الموضوع-

RS28E

المملكة المغربية
وزارة التربية الوطنية
والتكوين المهني
والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

3	مدة الإنجاز	الفيزياء والكيمياء	المادة
7	المعامل	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	الشعبة أو المسلك

The use of non-programmable scientific calculator is allowed

This exam paper consists of four exercises

Literal expressions should be given before doing numerical calculations

EXERCISE I (7 points):

- Study of the electrochemical cell: zinc-copper.
- Study of hydrolysis of an ester.

EXERCISE II (2,5 points):

- Study of the disintegration of plutonium-241.

EXERCISE III (4,5 points):

- Response of the RL dipole to a step-up voltage.
- Demodulating an amplitude-modulated wave.

EXERCISE IV (6 points):

- Study of a charged particle motion in a uniform magnetic field.
- Energetic study of a simple pendulum.

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EXERCISE I (7 points)

Part one and part two are independent

Marking scale

Part one : Study of the electrochemical cell, zinc-copper

During the functioning of the electrochemical cell, a part of the chemical energy is converted to an electrical energy.

In this part, we study the functioning principle of the electrochemical cell, zinc-copper.

We build the zinc-copper cell using the following tools and materials:

-A beaker contains an aqueous solution of zinc sulphate $Zn^{2+}_{(aq)} + SO^{2-}_{4(aq)}$ of molar concentration $C_1 = 1\,mol.L^{-1}$;

-Another beaker contains an aqueous solution of copper sulphate $Cu^{2+}_{(aq)} + SO^{2-}_{4(aq)}$ of molar concentration $C_2 = 1\,mol.L^{-1}$;

-A plate of zinc and another one of copper;

-A salt bridge.

In series, a resistor and an ammeter are connected between the electrochemical cell electrodes. When we switch on the circuit, the ammeter indicates a steady electric current of intensity I = 0,3 A.

Given:

- Faraday constant: $1\,F = 9,65.10^4\,C.mol^{-1}$;
- The atomic molar mass of copper: $M(Cu) = 63,5\,g.mol^{-1}$;
- The equilibrium constant associated with the reaction: $Cu^{2+}_{(aq)} + Zn_{(s)} \underset{(2)}{\overset{(1)}{\rightleftharpoons}} Cu_{(s)} + Zn^{2+}_{(aq)}$ is $K = 1,7.10^{37}$.

0,5 **1.** Calculate $Q_{r,i}$ the reaction quotient at the initial state of the chemical system.

0,5 **2.** Deduce the spontaneous direction of the evolution of the chemical system.

0,5 **3.** Write the half-equation of the chemical reaction at the cathode.

0,75 **4.** Calculate $m(Cu)$ the mass of copper deposited when the electrochemical cell is carried out for $\Delta t = 5h$.

Part two : Study of hydrolysis of an ester

Characteristics and products of hydrolysis of an ester depend on the nature of the medium in which this reaction was taking place.

This part aims at studying both the hydrolysis of an ester in acidic medium and the base hydrolysis of this ester.

1-Hydrolysis of methyl ethanoate

In an erlenmeyer flask, a mixture of 0,6 mol of pure methyl ethanoate $CH_3 - CO_2 - CH_3$ and 0,6 mol of distilled water is heated under reflux for a certain time, in the presence of few drops of concentrated sulphuric acid. A chemical reaction occurs.

At equilibrium state, the remaining amount of substance of the methyl ethanoate is 0,4 mol.

0,5 **1.1.** What is the role of the sulphuric acid?

0,5 **1.2.** State two characteristics of this reaction.

0,5 **1.3.** Choose, from the following experimental set-ups (a), (b) and (c), the one that represents heating under reflux.

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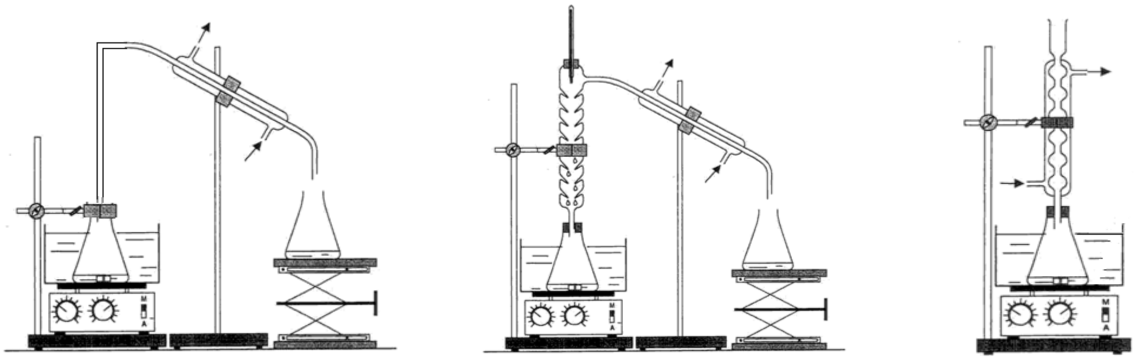

(a) (b) (c)

0,75 **1.4.** Using the structural formulae, write the equation of the studied chemical reaction.

0,75 **1.5.** Calculate K the equilibrium constant associated to this chemical reaction.

2-The base hydrolysis of methyl ethanoate

In a beaker, we introduce, at an instant of time t = 0, an amount of substance n_0 of methyl ethanoate and the same amount of substance as n_0 of an aqueous solution of sodium hydroxide $Na^+_{(aq)} + HO^-_{(aq)}$ of molar concentration $c_0 = 10\ mol.L^{-1}$ and volume V_0.

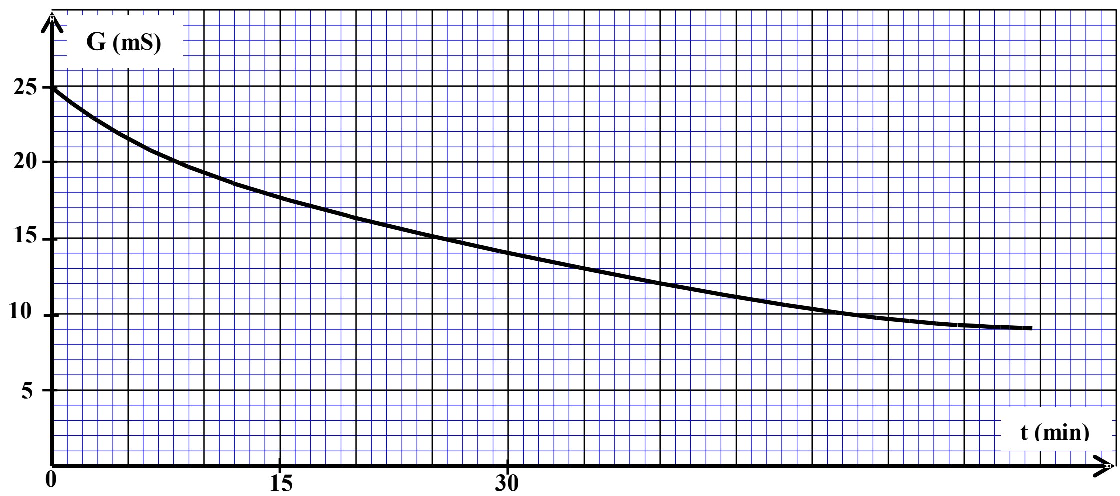
We obtain an equimolar mixture of volume $V \approx V_0 = 10^{-1} L$.

The chemical equation of the reaction between the methyl ethanoate and the sodium hydroxide is written as: $CH_3-CO_2-CH_{3(\ell)} + HO^-_{(aq)} \longrightarrow A_{(\ell)} + B^-_{(aq)}$

0,5 **2.1.** Write the structural formulae of the chemical species $A_{(\ell)}$ and $B^-_{(aq)}$.

2.2. We perform the temporal monitoring of this reaction by measuring the conductance G of the mixture at many instants.

The following figure shows the experimental curve of G(t) obtained by using an appropriate software.



At any instant t of time, the relationship, between the progress of reaction x(t) and the conductance of the mixture G(t), is written as:

$x(t) = -6{,}3.10^{-2}.G(t) + 1{,}57.10^{-3}$, where G(t) is expressed in siemens (S) and x(t) in mole (mol).

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0,75 **2.2.1.** Calculate the value of $G_{1/2}$ the conductance of the reaction mixture when $x=\frac{x_{max}}{2}$; where x_{max} is the maximum progress of the reaction.

0,5 **2.2.2.** Deduce, in minute, the value of the half-life $t_{1/2}$ of the reaction.

EXERCISE II (2,5 points)

Study of the disintegration of plutonium-241:

The plutonium-241 is radioactive element which does not exist in nature. It is produced by nuclear transformations of the uranium- 238.

The disintegration of the plutonium $^{241}_{94}\text{Pu}$ produces the americium $^{241}_{95}Am$ and a particle X .

Given :

- -Mass of the nucleus $^{241}_{95}Am$: $m(^{241}_{95}Am)=241,00471\,\text{u}$;
- -Mass of the nucleus $^{241}_{94}\text{Pu}$: $m(^{241}_{94}\text{Pu})=241,00529\,\text{u}$;
- -Mass of the particle X: $\text{m(X)} = 0,00055\,\text{u}$;
- - $1u=931,5\,MeV.c^{-2}$;
- - Half-life of the nucleus $^{241}_{94}\text{Pu}$ is $t_{1/2}=14,35\,years$.

0,75 **1.** Write the equation of this disintegration, and determine the type of the radioactivity of $^{241}_{94}\text{Pu}$.

0,75 **2.** Calculate, in MeV, the energy released (produced) E_{pro} during this disintegration of the nucleus $^{241}_{94}\text{Pu}$.

1 **3.** The initial activity of a sample of plutonium is $a_0=3.10^6\,Bq$. Find out its activity a_1 at $t_1=28,70\,years$.

EXERCISE III (4,5 points)

Inductors (coils) are considered as main parts in the make-up of a number of electric devices that we use in our daily life.

This exercise aims at determining the experimental value of the inductance of an inductor of an electric blender over studying response of RL dipole submitted to a step-up voltage, and studying main stages for demodulating an amplitude-modulated wave.

Part one and part two are independent

Part one : **Response of the RL dipole to a step-up voltage**

In order to determine the inductance L of an inductor (coil), we perform the experimental set-up sketched in figure 1.

The set-up consists of:

- -An ideal power supply of electromotive force E;
- -An inductor of inductance L and of negligible resistance;
- -A resistor of resistance $R=10\,\Omega$;
- -A switch K.

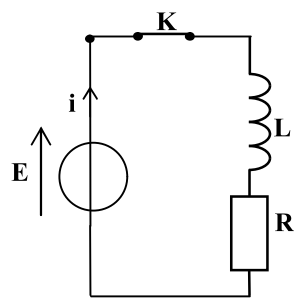

Figure 1

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At an instant of time t=0, we switch on the circuit. Using a datalogger to visualize the voltage $u_L(t)$ between terminals of the inductor.

The figure 2 shows the variation of $u_L(t)$ as a function of time.

0,25 **1.** Copy the circuit in figure 1 (page 4) on your answer sheet and show there how to connect the datalogger to visualize the voltage $u_L(t)$.

0,5 **2.** Find out the differential equation of the intensity i(t) of the current flowing through this circuit.

0,5 **3.** Knowing that the expression of the electric current intensity is: $i(t) = \frac{E}{R}(1 - e^{-\frac{R}{L}.t})$. Find out the expression of the voltage u_L in terms of t, E, R and L.

0,5 **4.** Calculate the value of the voltage between terminals of the inductor at $t = \tau$ where τ is the time-constant.

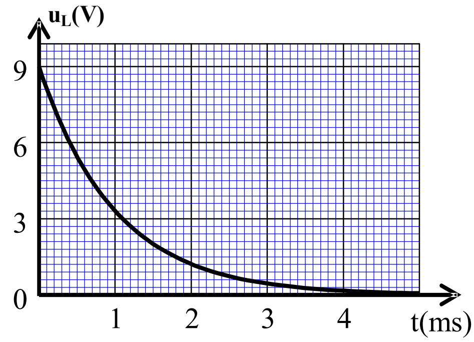

Figure 2

0,75 **5.** Determine graphically the value of τ then deduce the value of the inductance L of the inductor.

0,75 **6.** Calculate the magnetic energy stored in the inductor at $t = \tau$.

Part two : Demodulating an amplitude modulated wave

The figure 3 shows the simplified circuit scheme of an experimental set-up of a device (AM radio) to receive amplitude-modulated radio wave.

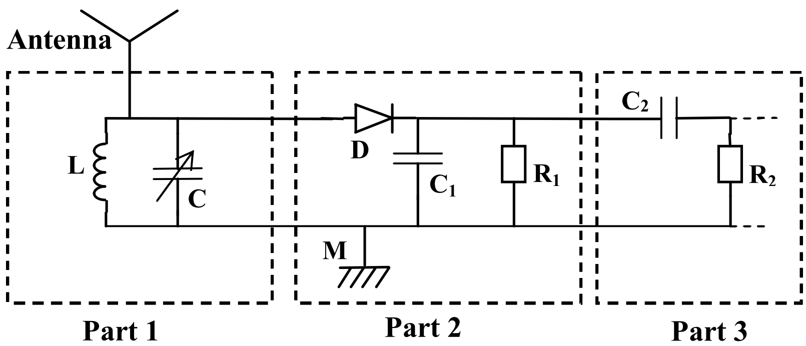

Figure 3

Copy on your answer sheet, the number of question with the letter of the correct answer

0,5 **1.** The bung circuit (part 1) is consisted of an antenna and an inductor of inductance $L = 10mH$ and of negligible resistance. The inductor is connected in parallel to a capacitor of adaptable capacitance C.

The capacitance C of the capacitor which allows to select the radio wave of frequency $f_0 = 530kHz$ is:

A	9 μF	**B**	9 nF	**C**	9 pF	**D**	9 mF

0,5 **2.** Knowing that the value of the average frequency of the sound is 1kHz and the value of the resistance R_1 which permits to get a high quality of envelope detection of the studied radio wave is R_1=35Ω.

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The value of the capacitance C_2 of the capacitor used in the part 2 of the set-up is :

A	$50\,\mu F$	**B**	$20\,\mu F$	**C**	$50\,mF$	**D**	$20\,nF$

0,25 **3.** The role of part 3 of the set-up is:

A	Modulating the amplitude	**B**	Selecting the wave frequency	**C**	Removing the DC voltage	**D**	Detecting the envelope

EXERCISE IV (6 points)

Part one and part two are independent

Part one : Study the motion of a charged particle in a uniform magnetic field

A mass spectrometer can be used to distinguish between charged particles according to their masses and their charges. How to work this device is based on the Lorentz force. This part aims at determining the mass of a charge particle by studying its motion in a uniform magnetic field.

Two charged particles He^{2+} and O^{2-}, having the same initial velocity $\vec{V}$, enter at point A in a uniform magnetic field $\vec{B}$ which is perpendicular to $\vec{V}$.

We assume that the Lorentz force is the only force acting up on both particles.

Given:

- The Lorentz force is $\vec{F} = q\vec{V} \wedge \vec{B}$;
- The mass of He^{2+} is $m(He^{2+}) = 6{,}68.10^{-27}\,kg$;
- Figure 1 shows tracks of the two particles He^{2+} and O^{2-} inside the magnetic field $\vec{B}$.

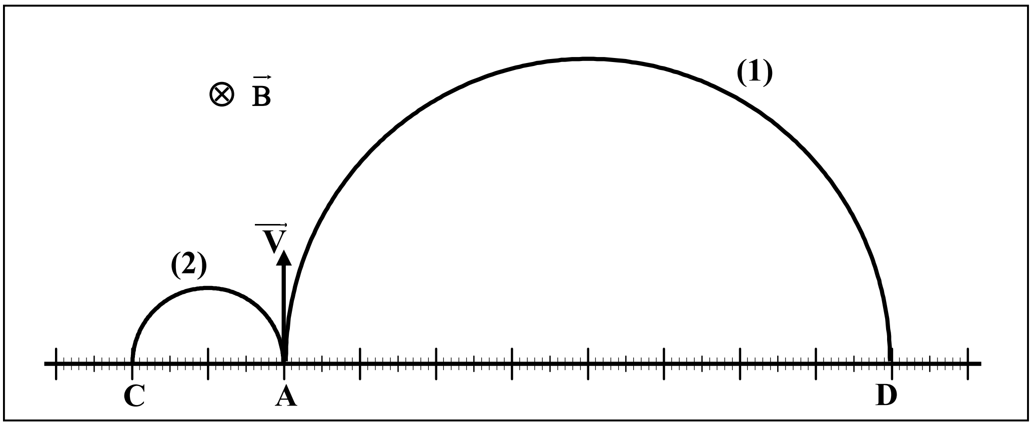

Figure1

0,5 **1.** Determine the track (path) of each particle.

1 **2.** Applying Newton's second law in a Galilean frame of reference, show that the motion of He^{2+} is uniform circular and its radius is given by: $R_{He^{2+}} = \dfrac{m(He^{2+}).V}{2.e.B}$.

0,5 **3.** Using figure 1, determine the ratio $\dfrac{R_{O^{2-}}}{R_{He^{2+}}}$, where $R_{O^{2-}}$ is the radius of the track of O^{2-}.

1 **4.** Show that the mass of the particle O^{2-} is $m(O^{2-}) = 2{,}67.10^{-26}\,kg$.

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Part two : Energetic study of a simple pendulum

A girl oscillates back and forth using a swing hanged to a fixed support. The mechanical system (girl-swing) can be modelled on simple pendulum which is composed of a massless string of lenght L and of a solid (S) its mass is m and its dimensions are negligible to the lenght L.
The simple pendulum is a particular case of the physical pendulum.
In equilibrium, the simple pendulum is undisturbed (at rest).
At an instant of time t=0, the pendulum is launched from its equilibrium position by an initial velocity in the positive direction when the kinetic energy $E_{k_0} = 13,33\,J$. The pendulum made a sinusoidal oscillatory motion; its amplitude is $\theta_{max} = 0,20\,rad$.
We locate the position of the pendulum at an instant t of time by the angular displacement θ.(see figure2)
Assuming the gravitational potenial energy to be zero $(E_{pg}=0)$ on the horizontal plane passing through the equilibrium position $\theta = 0$ (reference level).
The study concernes small oscillations in a Galilean frame of reference linked to the Earth.
All frictions are negligible.

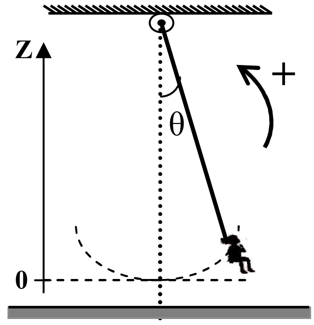

Figure 2

Given:

- The length of the simple pendulum is $L=2\,m$;
- The strength of the gravitational field is $g=9,8\,m.s^{-2}$;
- In the case of small oscillations: $\cos\theta \approx 1-\frac{\theta^2}{2}$, where θ is expressed in radians;
- Trigonometric formula: $\cos^2\theta + \sin^2\theta = 1$.

0,5 **1.** By using the dimensional analysis, show that the following expression $T_0 = 2\pi.\sqrt{\frac{L}{g}}$ is homogeneous to the time.

0,75 **2.** The equation of motion of the pendulum is expressed as: $\theta(t) = \theta_{max}.\cos(\frac{2\pi}{T_0}t+\varphi)$.
Determine, in S.I units, the values of T_0 and φ .

0,5 **3.** Show that the expression of gravitational potential energy of the simple pendulum is given by:

$$E_{pg}(t) = \frac{1}{2}m.g.L.\theta_{max}^2.\cos^2(\frac{2\pi}{T_0}t+\varphi).$$

0,75 **4.** Show that the expression of the mechanical energy is given by: $E_m = \frac{1}{2}m.g.L.\theta_{max}^2$.

0,5 **5.** By using the principle of conservation of the mechanical energy, calculate the mass m of the solid (S).

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المركز الوطني للتقويم والامتحانات والتوجيه

المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	المعامل	7

EXERCISE I (7 points)

	Questions	Answers	Marking scale	Question reference In the framework
Part I	1	$Q_{r,i}=1$	0,5	-Calculate the value of the quotient of reaction Q_r of a chemical system in given state.
	2	Direction (1)	0,5	-Determine the direction of spontaneous evolution of a chemical system.
	3	At the cathode : $Cu^{2+}_{(aq)}+2e^- \rightleftarrows Cu_{(s)}$	0,5	-Write the half-equation that occurred in each electrode (use double arrows) and write the overall equation of the reaction during the battery functioning (use one arrow).
	4	$m(Cu)=\dfrac{I.\Delta t.M(Cu)}{2.F}$ $m(Cu)\approx 1,78$ g	0,5 0,25	-Establish the relationship between the amount of substance of chemical specie produced or consumed, the current intensity and the operating duration of a battery. Use this relationship to determine other quantities (quantity of charge, progress of the reaction, change of the mass...).
Part II	1.1	Catalyst (it speeds up the reaction)	0,5	-Know that a catalyst is a chemical specie that increases the rate of a chemical reaction without changing the equilibrium state of the system.
	1.2	Slow and non-complete (limited)	0,25x2	-Know the characteristics of esterification and hydrolysis: non- complete and slow transformations.
	1.3	Set-up (**C**)	0,5	-Know the experimental set-up of an acid-base titration.
	1.4	Equation of reaction	0,75	- Write the esterification and the hydrolysis equation.
	1.5	-Expression of K. - $K=0,25$	0,5 0,25	- 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.
	2.1	$A_{(\ell)}$: $CH_3\text{-}OH_{(\ell)}$ $B^-_{(aq)}$: $CH_3\text{-}CO^-_{2(aq)}$	0,25 0,25	-Write the equation of the reaction of an anhydrous acid with an alcohol and that of the basic hydrolysis of an ester.
	2.2.1	- Method - $G_{1/2}\approx 17\,mS$	0,5 0,25	-Exploit the different curves of time-evolution of the following: the amount of substance of a chemical specie, its

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				concentration, the progress of a reaction, conductivity, conductance, pressure and volume.
	2.2.2	Let consider any value of $t_{1/2}$ in the following interval $17\,\text{min} \le t_{1/2} \le 18\,min$	0,5	-Define the half-life t1/2 of a chemical reaction. -Determine the half-life $t_{1/2}$ of the chemical reaction graphically or through exploiting the

EXERCISE II (2,5 points)			
Questions	**Answers**	**Marking scale**	**Question reference In the framework**
1.	- Equation of disintegration - The radioactivity's type is β^-	**0,5** **0,25**	- Know and exploit the two laws of conservation. - Write the equation of a nuclear reaction by applying the two conservation laws. - Recognise the type of radioactivity using the equation of a nuclear reaction.
2.	- Method - $E_{pro} \simeq 2,8.10^{-2}\ MeV$	**0,5** **0,25**	- Calculate the energy released (produced) by a nuclear reaction: $E_{pro} = \lvert\Delta E\rvert$.
3.	- Method - $a_1 \simeq 7,5.10^5\ Bq$	**0,5** **0,5**	- Know and exploit the law of the radioactive decay, and exploit its curve. - Know that 1Bq is equal to one decay per second. - Exploit the relationships between τ , $t_{1/2}$ and λ (decay constant).

	EXERCISE III (4,5 points)			
	Questions	**Answers**	**Marking scale**	**Question reference In the framework**
Part I	**1.**	How to connect the datalogger to monitor the voltage $u_L(t)$	**0,25**	Know how to connect an oscilloscope and a datalogger to monitor different voltages.
Part I	**2.**	Differential equation : $\frac{di}{dt}+\frac{R}{L}i=\frac{E}{L}$	**0,5**	- Find out the differential equation and verify its solution when the RL dipole is submitted to a step voltage.
Part I	**3.**	$u_L(t)=E.e^{-\frac{R.t}{L}}$	**0,5**	- Determine the current's intensity expression $i(t)$ when the RL dipole is submitted to a step voltage, and deduce the voltage expressions between the inductor's terminals and the resistor terminals.
Part I	**4.**	$u_L(\tau)=E.e^{-1}=0,37.E$ $u_L(\tau)\approx 3,3\,V$	**0,25** **0,25**	
Part I	**5.**	$\tau=1ms$ $L\approx 10^{-2}\,H$	**0,25** **0,5**	- Know and exploit the time-constant expression. - Exploit experimental documents in order to determine the time-constant.
Part I	**6.**	- Expression of E_m - $E_m \approx 1,6.10^{-3}\,J$	**0,5** **0,25**	- Know and exploit the expression of the magnetic energy stored in a inductor.

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Part II	1.	Answer : **C**	0,5	- Know the stages of demodulation. - Know the conditions allowing to get an amplitude modulation and a high quality detection envelope. - Know the selective role of the LC (bung circuit) for the modulated voltage. - Recognise the essential components required to assemble an AM radio, and their roles in the demodulation. - Know the role of different used filters.
	2.	Answer : **B**	0,5	
	3.	Answer : **C**	0,25	

	EXERCISE IV (6 points)			
	Questions	**Answers**	**Marking scale**	**Question reference In the framework**
Part I	1.	Path (1) : O^{2-} Path (2) : He^{2+}	0,25 0,25	- Know the characteristics of Lorentz force and the rule to determine its direction. - Apply Newton's second law in the charged particle case inside a uniform magnetic field, with $\vec{B}$ perpendicular to $\vec{v}_0$ in order to determine the type of motion. - Know the components of the acceleration vector in Cartesian coordinate system and in Frenet frame.
	2.	- Newton's second law - Using Frenet frame - Uniform motion -Circular motion	0,25 0,25 0,25 0,25	
	3.	$\frac{R_{O^{2-}}}{R_{He^{2+}}}=4$	0,5	
	4.	Method	1	
Part II	1.	Method	0,5	- Use of the dimensional analysis (dimensional equations). - Know the meaning of the physical quantities involved in the expression of the time-equation $\theta(t)$ for the physical pendulum and determine them using the initial conditions. - Know the expression of the natural period for the simple pendulum. - Exploit the expression of the gravitational potential energy and the expression of the kinetic energy to determine the mechanical energy of the physical pendulum in the small oscillations case. - Exploit the conservation of the mechanical energy of a physical pendulum in the small oscillations case.
	2.	$T_0 \approx 2,8\,s$ $\varphi = -\frac{\pi}{2}\,rad$	0,25 0,5	
	3.	Method	0,5	
	4.	Method	0,75	
	5.	- Method - $m \approx 34\,kg$	0,25 0,25	

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