الامتحان الوطني الموحد للبكالوريا
المسالك الدولية
الدورة الاستدراكية 2022
– الموضوع –

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

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):

- The electrolysis of an aqueous solution of the gold (III) chloride
- Study of some properties of an aqueous solution of the methylamine

EXERCISE 2 (3,5 points):

- Propagation of a mechanical wave
- Carbon-14 dating

EXERCISE 3 (4,5points):

- Response of the RL dipole to a step voltage
- Free oscillations in a RLC series circuit
- Reception of an amplitude modulated wave

EXERCISE 4 (5 points):

- Study of the motion of a solid on an inclined plane
- Study of the motion of a mechanical oscillator

Marking scale

EXERCISE 1 (7 points)

Part 1 and part 2 are independent

Part l : The electrolysis of an aqueous solution of the gold (III) chloride

In this part, we study the electrolysis of an aqueous solution of the gold (III) chloride in order to deposit a thin layer of the gold on a plate of copper.

The copper plate is dipped totally into an aqueous solution of the gold (III) chloride $Au^{3+}_{(aq)} + 3Cl^{-}_{(aq)}$ and it is connected to one pole of a generator G, the other pole is connected to an electrode of graphite that is dipped into the same aqueous solution.

The generator supplies an electric current of intensity $I = 50\,mA$ during a period Δt of time.

Throughout this electrolysis, we observe that the gold is deposited on the copper plate and the chlorine gas $Cl_{2(g)}$ is produced at the graphite electrode.

Given :

- Redox pairs involved are : $Au^{3+}_{(aq)}/Au_{(s)}$ and $Cl_{2(g)}/\ Cl^{-}_{(aq)}$;
- Molar mass of the gold : $M(Au)=197 g.mol^{-1}$;
- $1F = 9{,}65.10^{4}\ C.mol^{-1}$.

0,75 **1.** Sketch the experimental set-up of this electrolysis by showing the cathode, the anode and the sense (direction) of the electric current passing through the external circuit of the electrolytic cell.

0,75 **2.** Write the equation of the chemical reaction takes place at each electrode then write the overall equation.

0,75 **3.** Find, in minutes (min), the duration Δt for that the mass $m(Au) = 0{,}031 g$ is deposited.

Part 2 : Study of some properties of an aqueous solution of the methylamine

The methylamine, of condensed structural formula $CH_3 - NH_2$*, can be used in the pharmaceutical industry of many products such as antispasmodic, as anesthetic or as a raw material in the manufacture of insecticide.*

In this part, we suggest studying some properties of the aqueous solution of the methylamine.

1. Study of an aqueous solution of the methylamine

We prepare a volume $V = 1L$ of an aqueous solution S_b of the methylamine of concentration $C_b = 10^{-2} mol.L^{-1}$.The measurement of pH of the solution S_b, at $25^{\circ}C$, gives pH = 11,3 .

Given :

- The ionic product of water at $25^{\circ}C$ is $K_w = 10^{-14}$.

0,25 **1.1.** Define a base according to Bronsted.

0,25 **1.2.** Write the equation of the reaction of the methylamine and water.

0,5 **1.3.** Calculate the final progress rate τ of this reaction. What can you deduce?

0,5 **1.4.** Show that the reaction quotient $Q_{r,eq}$ at equilibrium is written as : $Q_{r,eq} = \dfrac{C_b.\tau^2}{1-\tau}$.

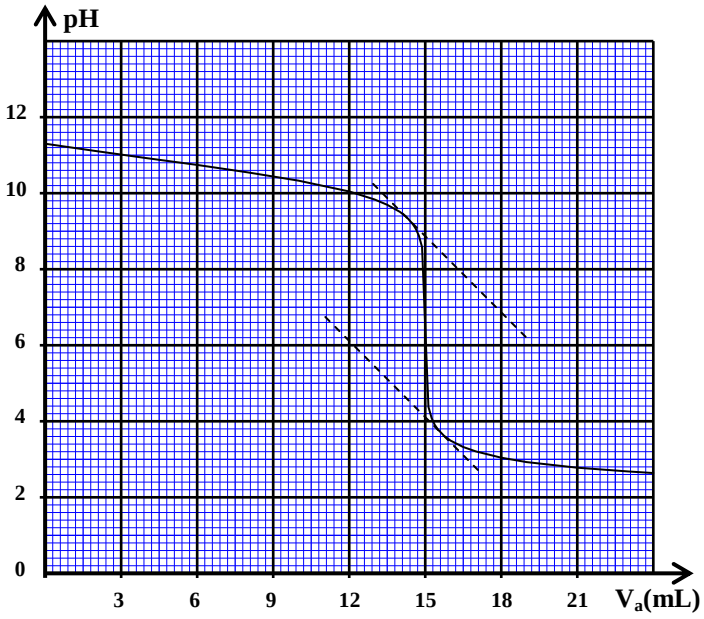
Calculate its value.

0,5 **1.5.** Find the expression of the acidity constant K_A of the pair $CH_3-NH^+_{3(aq)} / CH_3-NH_{2(aq)}$ in terms of $Q_{r,eq}$ and K_w then verify that $pK_A \approx 10,7$.

2. Titration of an aqueous solution of the methylamine

To verify the value of the concentration C_b of the aqueous solution S_b, we carry out a pH-metric titration of a volume $V_b = 15mL$ of the aqueous solution S_b by 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 represents the variations of the pH of the reactional medium as a function of the volume V_a of the solution S_a added.



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

0,5 **2.2.** Determine graphically the coordinates (V_{aE}, pH_E) of the equivalence point.

0,5 **2.3.** Deduce the concentration C_b.

0,5 **2.4.** Choose from the following acid-base indicators, the one that is suitable for this titration. Justify your answer.

Acid-base indicator	Helianthine	Bromothymol blue	Cresol red	Phenolphthalein
pH range	3,0 - 4,6	6,0 - 7,6	7,2 -8,8	8,2 – 10,0

0,75 **2.5.** Determine the quotient $\frac{[CH_3-NH_{2(aq)}]}{[CH_3-NH^+_{3(aq)}]}$ when the volume $V_{a1} = 20,4\,mL$ of the solution S_a has been added. Deduce the predominant chemical specie.

EXERCISE 2 (3,5 points)

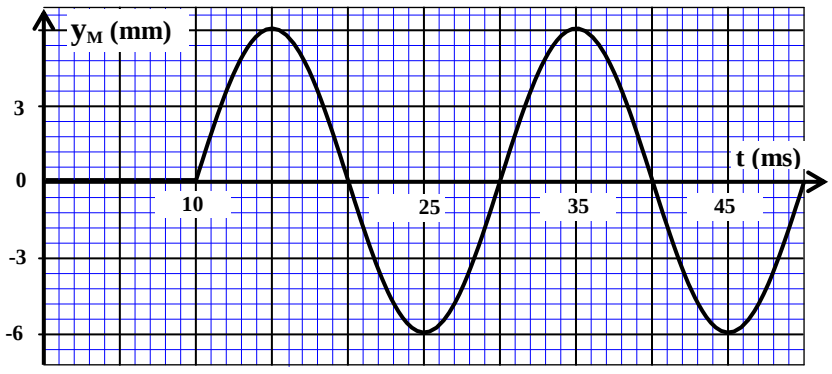
Part 1 and part 2 are independent

Part 1 : Propagation of a mechanical wave

At an instant taken as origin of time t=0, we produce at a point S on the surface of water a sinusoidal progressive mechanical wave of frequency N.

The curve in figure represents the variations of the elongation y_M of a point M of the medium located at a distance $L = 2,5\,cm$ from the point S.

Copy the number of the question and choose the correct answer from the proposals without neither justification nor explanation.



0,5 **1.** The frequency of this wave is :

A	$N=25\,Hz$	**B**	$N=50\,Hz$	**C**	$N=100\,Hz$	**D**	$N=200\,Hz$

0,5 **2.** The point M repeats the same movement of S in a time delay τ of value :

A	$\tau=0,1s$	**B**	$\tau=0,02s$	**C**	$\tau=0,01s$	**D**	$\tau=0,2s$

0,5 **3.** The wave speed on the surface of water is :

A	$v=2,5\,m.s^{-1}$	**B**	$v=0,25\,m.s^{-1}$	**C**	$v=25\,m.s^{-1}$	**D**	$v=0,4\,m.s^{-1}$

0,5 **4.** The wavelength λ is :

A	$\lambda=5\,cm$	**B**	$\lambda=2,5\,cm$	**C**	$\lambda=0,5\,m$	**D**	$\lambda=0,25\,cm$

Part 2 : Carbon-14 datating

In this part, we suggest determining the approximate age t_1 of an old piece of wood by using the carbon-14 dating technique.

The type of the disintegration of the carbon-14 nucleus $(^{14}_{6}C)$ is β^-.

Given :

- The mass of the carbon-14 nucleus is $m(^{14}_{6}C)=13,99995\,u$;
- The mass of the neutron is $m_n=1,00866\,u$;
- the mass of the proton is $m_p=1,00728\,u$;
- $1\,u=931,5\,MeV.c^{-2}$;
- The half-life of the carbon-14 is $t_{1/2}=5730\,years$.

1. Copy the number of the question and choose the correct answer from the proposals without neither justification nor explanation.

0,25 **1.1.** The nucleus of the carbon-14is made of :

A	14 protons et 6 neutrons	**B**	8 protons et 6 neutrons
C	6 protons et 8 neutrons	**D**	6 protons et 14 neutrons

0,25 **1.2.** The equation of disintegration of the carbon-14 is :

A	$^{14}_{6}C \rightarrow {}^{0}_{+1}e + {}^{14}_{5}B$	**B**	$^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$
C	$^{14}_{6}C \rightarrow {}^{4}_{2}He + {}^{10}_{4}Be$	**D**	$^{14}_{6}C + {}^{0}_{-1}e \rightarrow {}^{14}_{5}B$

0,5 **2.** Calculate, in MeV, the binding energy E_b of the carbon nucleus $^{14}_{6}C$.

0,5 **3.** The ratio of the carbon-14 keeps the same in creatures'tissues. When a creature dies, this ratio decreases progressively according to the radioactive decay law.

The activity of the carbon-14 of an old piece of wood is $a_1=318\,Bq$ whereas the activity of the carbon-14 of a recent piece of wood, of the same mass as the old one, is $a_0=418\,Bq$.

Determine, in years, the approximate age t_1 of the old piece of wood.

EXERCISE 3 (4,5 points)

In this exercise, we suggest studying:
- the response of the RL dipole to a step voltage
- the free oscillations in a RLC series circuit
- the reception of an amplitude modulated wave

1. Response of the RL dipole to a step voltage

We perform the experimental set-up in figure 1.
This set-up is consisted of :
-an ideal generator of voltage of electromotive force E=10V;
- an inductor of inductance L adjustable and of resistance r;
- a resistor of resistance $R = 490\Omega$;
- a switch K.

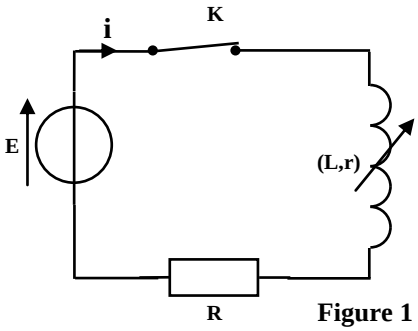


Figure 1

we adjust the value of the inductance of the inductor at $L = L_0$ and we switch on the circuit at an instant taken as origin of time $t = 0$. A datalogger permits to visualise the curve C_1 of the evolution of the voltage $u_R(t)$ between terminals of the resistor (figure2). (T) is the tangent of the curve at the point of $t = 0$.

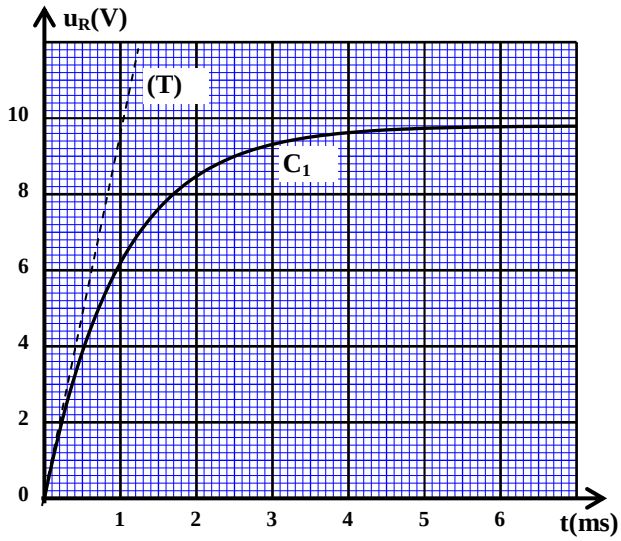


Figure 2

0,25 **1.1.** Copy the scheme in figure 1 and show how to connect the datalogger to visualise the voltage $u_R(t)$.(The connection of the datalogger is the same as that of the oscilloscope).

0,5 **1.2.** Show that the differential equation of the voltage $u_R(t)$ is written as :

$$\frac{du_R}{dt} + \frac{(R+r)}{L_0}u_R = \frac{E\,R}{L_0}.$$

0,25 **1.3.** Determine graphically the voltage U_0 between terminals of the resistor at the steady state.

0,5 **1.4.** Deduce the value of r the resistance of the inductor.

0,25 **1.5.** Verify that $L_0 = 0,5\,H$.

0,5 **1.6.** We repeat the same experiment by adjusting the inductance of the inductor at the value $L = L_1 = 2L_0$. A datalogger permits to monitor the evolution of the voltage $u_R(t)$ in the two cases : $L = L_0$ and $L = L_1$.

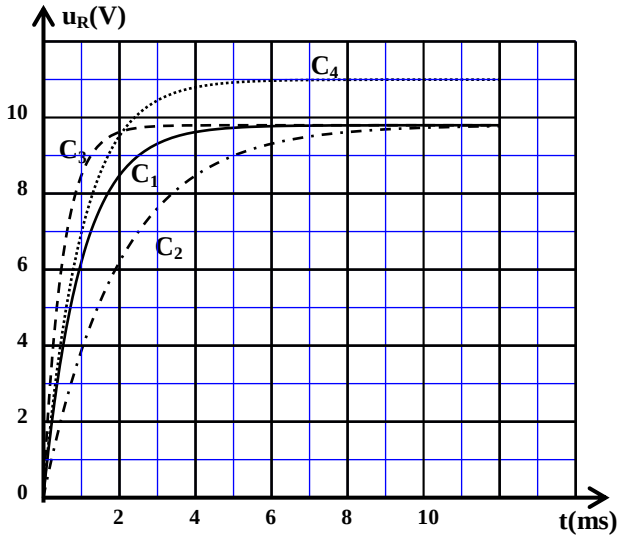


Figure 3

Choose among the curves C_2, C_3 and C_4 in figure 3, the one that represents the evolution of the voltage $u_R(t)$ in the case where $L = L_1$. Justify your answer.

2. Free oscillations in a RLC series circuit

We perform the set-up in figure 4.

This set-up is consisted of:

- a capacitor of capacitance C initially discharged;
- the previous inductor of inductance $L = 1H$;
- a switch K.

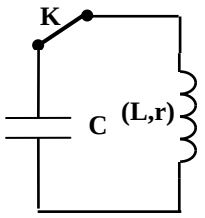


Figure 4

The curve in figure 5 represents the evolution of the charge q(t) of the capacitor.

0,5 **2.1.** Find out the differential equation of the charge q(t).

0,75 **2.2.** Assuming that the pseudo-period is the same as the natural period T_0 of the electric oscillator, determine the value of the capacitance C. (Take $\pi^2 = 10$).

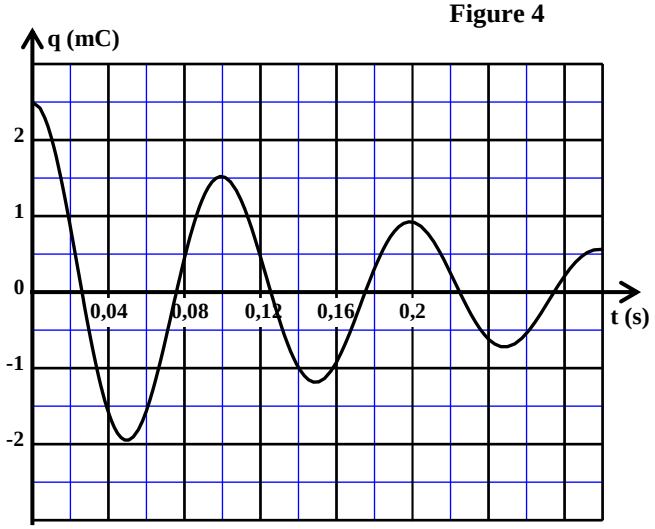


Figure 5

3 . Reception of an amplitude modulated wave

To receive a radio wave, modulated in amplitude and of frequency f_0=171 kHz , we use the set-up in figure 6.

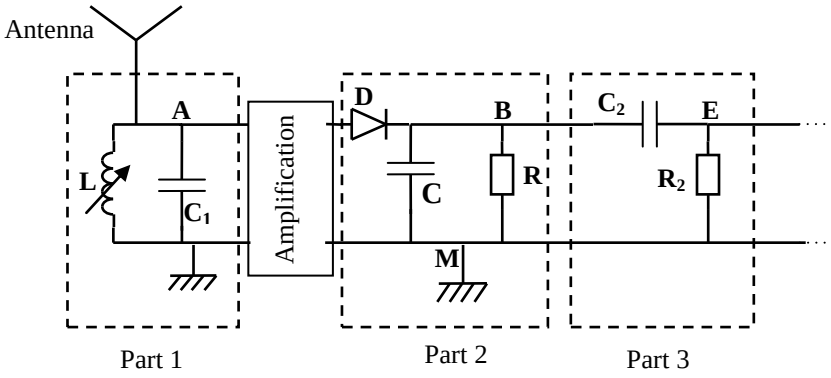


Figure 6

Part 1 of this set-up is consisted of a capacitor of capacitance $C_1 = 85,4\,pF$ and an inductor of adjustable inductance L.

0,5 **3.1.** What is the role of the part 1 and that of the part 3 of this set-up?

0,5 **3.2.** Determine the value of the inductance L of the inductor to receive the radio wave of frequency f_0. (Take $\pi^2 = 10$).

EXERCISE4 (5 points)

Part 1 and part 2 are independent

Part 1 : Study the motion of a solid on an inclined plane

A solid (S) of mass m and of center of inertia G moves with friction on an inclined plane at an angle α to the horizontal. We study the upward motion of the solid (S) from the position O to the position B. (figure 1).

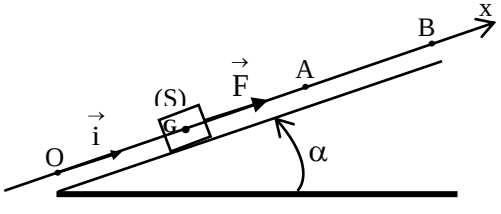


Figure1

The frictions are modeled in a constant force $\vec{f}$ of magnitude f .

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

At an instant t, we locate the position of G on the plane by its abscissa x(t).

Given : Gravitational acceleration (Acceleration due to gravity) $g = 10 m.s^{-2}$;

$\alpha = 17,5°$; OA = 4 m ; m = 2 kg ; $f = 2 N$.

1. Study of the motion on the part OA

At the instant t=0, we consider that G coincides with the origin O of the axis $(O, \vec{i})$ and its speed is null at this instant. On the part OA, the solid (S) experiences a constant motive force $\vec{F}$ whose direction is parallel to the line of the greatest slope of the inclined plane and it is directed upward (figure 1).

0,5 **1.1.** Show that the differential equation of the motion is written as :

$$\frac{d^2x}{dt^2} = \frac{F - f}{m} - g\sin\alpha .$$

1.2. The curve in figure2 represents the variations of x as a function of t^2.

0,5 **1.2.1.** By exploiting the curve in figure 2, determine the acceleration a_{1x} of the center of inertia G.

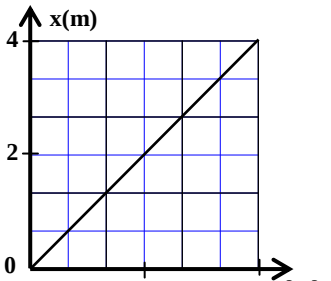


Figure 2

0,5 **1.2.2.** Show that the magnitude of the force $\vec{F}$ is $F \approx 12 N$.

0,5 **1.2.3.** Verify that the speed of G when it passes by the point A is $V_A = 4 m.s^{-1}$.

2. Study of the motion on the part AB

When G passes by A, we remove the force $\vec{F}$.

To study the motion of G on the part AB, we take the instant when G passes by the point A as a new origin of time $t = 0$.

0,5 **2.1.** Determine the acceleration a_{2x} of G on the part AB.

0,75 **2.2.** Knowing that the speed of G is null at the point B. Calculate the distance AB.

Part 2 : Study of the motion of a mechanical oscillator

An horizontal mechanical oscillator is consisted of a solid (S) of mass m = 0,5 kg fixed to one end of a spring (R) of non-contiguous turns and of negligible mass and of spring constant k. the other end is attached to a fixed stand.

To study the motion of the center of inertia G of the solid (S), we choose the coordinate system $(O, \vec{i})$ linked to an earth frame of reference assumed Galilean. At an instant t of time, we locate the position of G with its abscissa x in the coordinate system $(O, \vec{i})$. At equilibrium the position of G coincides with O the origin of the axis (Ox) (figure 3).

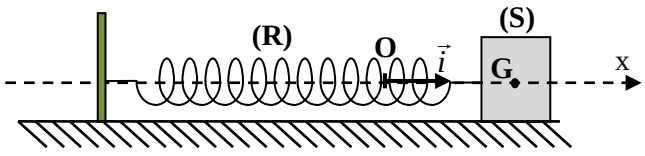


Figure 3

We pull the solid (S) from its equilibrium position and we release it without initial speed at $t = 0$. The solid (S) oscillates without friction.

By using an appropriate datalogger, we visualise the curve $x = f(t)$ (figure 4).

0,25 **1.** Determine the nature of the motion of G.

0,75 **2.** By applying Newton's 2nd law, find out the differential equation of G**.**

0,75 **3.** Find the value of the spring constant k. (take $\pi^2 = 10$).

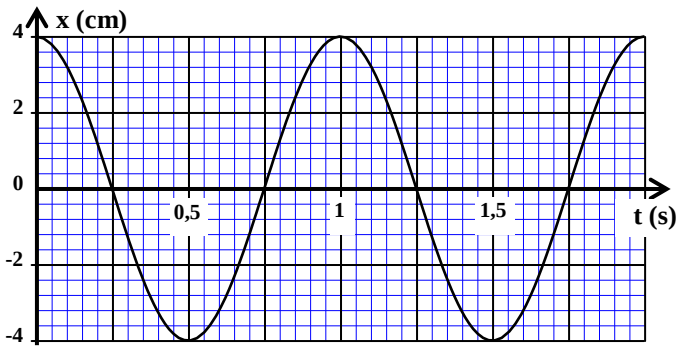


Figure 4

الصفحة:1على4	**الامتحان الوطني الموحد للبكالوريا** المسالك الدولية الدورة الاستدراكية 2022	المملكة المغربية وزارة التربية الوطنية والتعليم الأولي والرياضة المركز الوطني للتقويم والامتحانات
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المادة الشعبة والمسلك	الفيزياء والكيمياء شعبة العلوم التجريبية: مسلك العلوم الفيزيائية - خيار إنجليزية	مدة الإنجاز	المعامل	
		3h	المعامل	7

EXERCISE 1 (7 points)

Question		Answer	Marking scale	Question reference in the framework
Part 1	1.	- Scheme of the set-up of the electrolysis - Anode = electrode of graphite - the sense of the electric current in the external circuit : from the copper plate to the graphite	0,25 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. - Draw the experimental set-up of electrolysis. - 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.	- At the anode : $2Cl^-_{(aq)} \rightleftarrows Cl_{2(g)} + 2e^-$ - At the cathode : $Au^{3+}_{(aq)} + 3e^- \rightleftarrows Au_{(s)}$ -Overall equation : $2Au^{3+}_{(aq)} + 6Cl^-_{(aq)} \rightarrow 2Au_{(s)} + 3Cl_{2(g)}$	0,25 0,25 0,25	
	3.	$\Delta t = \frac{3.F.m(Au)}{I.M(Au)}$ $\Delta t \approx 15,2\,min$	0,5 0,25	
Part 2	1.1.	Definition of the base	0,25	- 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 $pK_A = -\log K_A$. - 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. - Justify the choice of a suitable indicator to determine the equivalence.
	1.2.	$CH_3-NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3-NH^+_{3(aq)} + HO^-_{(aq)}$	0,25	
	1.3.	$\tau = 19,95\%$ Limited reaction	0,25 0,25	
	1.4.	Method $Q_{r,eq} \approx 5.10^{-4}$	0,25 0,25	
	1.5.	$K_A = \frac{K_w}{Q_{r,eq}}$ Cheking the value of pK_A	0,25 0,25	
	2.1.	$CH_3-NH_{2(aq)} + H_3O^+_{(aq)} \rightarrow CH_3-NH^+_{3(aq)} + H_2O_{(l)}$	0,5	
	2.2.	$6,4 \le pH_E \le 6,6$ $V_{aE} = 15\,mL$	0,25 0,25	
	2.3.	$C_b = \frac{C_a.V_{aE}}{V_b}$ $C_b = 10^{-2}\,mol.L^{-1}$	0,25 0,25	
	2.4.	Acid-base indicator : Bromothymol blue Justification	0,25 0,25	
	2.5.	Method $\frac{[CH_3-NH_{2(aq)}]}{[CH_3-NH^+_{3(aq)}]} \approx 1,26.10^{-8}$ The predominant chemical specie is the acid.	0,25 0,25 0,25	

EXERCISE 2 (3,5 points)				
Question		**Answer**	**Marking scale**	**Question reference in the framework**
Part 1	**1.**	B	**0,5**	- Define a mechanical wave and its wave speed. - Know (Recall) and use the relationship $\lambda = v.T$ - Exploit the relationship between time delay, distance and wave speed. - Exploit experimental documents and data in order to determine: * distance; * time delay; * wave speed.
	2.	C	**0,5**	
	3.	A	**0,5**	
	4.	A	**0,5**	
Part 2	**1.1.**	C	**0,25**	- Know the meaning (significance) of the symbol $^{A}_{Z}X$ and give the corresponding composition of the nucleus. - Define the radioactivity: α , β^+ & β^- and the $\gamma - radiation$. - Write the equation of a nuclear reaction by applying the two conservation laws. - 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). - Determine the suitable radioactive element in order to date a given event. - Define and calculate the binding energy per nucleon and exploit it.
	1.2.	B	**0,25**	
	2.	$E_b = ((6.m_p + 8.m_n) - m(^{14}_{6}C)).c^2$ $E_b \approx 105,3\,MeV$	**0,25** **0,25**	
	3.	Method $t_1 \approx 2260,3\,ans$	**0,25** **0,25**	

EXERCISE 3 (4,5 points)			
Question	**Answer**	**Marking scale**	**Question reference in the framework**
1.1.	How to connect	**0,25**	- Know and exploit the voltage expression $u = r.i + L.\frac{di}{dt}$ between the inductor's (coil) terminals using the receiver convention. - Determine the two characteristics of the inductor (the inductance L, the resistance r) exploiting experimental results. - Find out the differential equation and verify its solution when the RL dipole is submitted to a step voltage. - Recognise and represent the variation curves of current's intensity $i(t)$ in terms of time across the inductor and different physical quantitiesassociated to it, and exploit them. - Know and exploit the time-constant expression. - Exploit experimental documents in order to: * highlight the influence of R and L on the response of a RL dipole; * determine the time-constant.
1.2.	Method	**0,5**	
1.3.	$U_0 = 9,8\,V$	**0,25**	
1.4.	Method $r = 10\,\Omega$	**0,25** **0,25**	
1.5.	Method	**0,25**	
1.6.	C_2 Justification	**0,25** **0,25**	
2.1.	Method $\frac{d^2q}{dt^2} + \frac{r}{L}.\frac{dq}{dt} + \frac{1}{LC}q = 0$	**0,25** **0,25**	- Find out the differential equation for the voltage between the capacitor's terminals or for its charge $q(t)$ in the negligible damping case and verify its solution. - Know and exploit the natural period expression. - Exploit experimental documents in order to: * determine the values of the period and the natural period.
2.2.	$C = \frac{T^2}{4\pi^2 L}$ $C = 250\,\mu F$	**0,5** **0,25**	
3.1.	Part 1: to select the modulated signal Part 3: to remove the DC voltage	**0,25** **0,25**	- 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.
3.2.	$L = \frac{1}{4\pi^2 f_0^2 C}$ $L = 0,01\,H$	**0,25** **0,25**	

EXERCISE 4 (5 points)

Question		Answer	Marking scale	Question reference in the framework
Part 1	1.1.	Method	0,5	- Know Newton's second law $\Sigma\overrightarrow{F_{ext}} = m.\dfrac{\Delta\overrightarrow{V_G}}{\Delta t}$ and $\Sigma\overrightarrow{F_{ext}} = m.\overrightarrow{a_G}$ and its range of validity. - Know and exploit the characteristics of the uniformly accelerated straight line motion and its parametric equations (t is the parameter). - Apply Newton's second law to find out the differential equation of a system's centre of inertia motion in horizontal or inclined plane and determine the characteristics of kinetic and dynamic quantities of motion.
	1.2.1	Method $a_{1x} = 2\,m.s^{-2}$	0,25 0,25	
	1.2.2	Method	0,5	
	1.2.3	Method	0,5	
	2.1.	Method $a_{2x} = -4\,m.s^{-2}$	0,25 0,25	
	2.2.	Method $AB = 2\,m$	0,5 0,25	
Part 2	1.	Rectilinear sinusoidal motion	0,25	- Know the oscillatory motion. - Recognise the free oscillations - Exploit the curves: $x_G(t)$, $v_G(t)$ and $a_G(t)$. - Apply Newton's second law to the oscillating system (solid-spring) to establish the differential equation of motion and verify its solution when the oscillating system vibrates in the following situations: horizontal, inclined or vertical. - Determine the type of motion of the oscillating system (solid-spring); write the equations: $x_G(t)$, $v_G(t) = \dfrac{dx}{dt}$ and $\ddot{x}_G(t)$ and exploit them. - Know the meaning of the physical quantities involved in the expression of the parametric equation $x_G(t)$ of the oscillating system (solid-spring) and determine them using the initial conditions. - Know and exploit both the expression of the natural period and that of the natural frequency of the oscillating system (solid-spring).
	2.	Method $\dfrac{d^2x}{dt^2} + \dfrac{k}{m}x = 0$	0,5 0,25	
	3.	Method $k = 20\,N.m^{-1}$	0,5 0,25	