المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2019
- الموضوع -

المركز الوطني للتقويم والامتحانات والتوجيه

NS30E

4	مدة الانجاز	الفيزياء والكيمياء	المادة
7	المعامل	شعبة العلوم الرياضية : (أ) و (ب) خيار أنجليزية	الشعبة أو المسلك

The use of the non-programmable scientific calculator is allowed.

This exam paper consists of four exercises; one in Chemistry and three in Physics.

Exercise 1 : Chemistry (7 points)

- Volumetric rate of a reaction and half-life of a chemical reaction
- Acid-base titration
- The electrolysis of an aqueous solution

Exercise 2 : Nuclear transformations (2,5 points)

- Study of a fusion reaction

Exercise 3 : Electricity (5 points)

- Charge of a capacitor
- Free oscillations and forced oscillations in RLC series circuit
- Reception of a hertzian wave

Exercise 4 : Mechanics (5,5 points)

- Fall of a ball
- Motion of an oscillator

Exercise 1 : Chemistry (7 points)

Parts I , II and III are independent

The hydrochloric acid has a several uses such as the elimination of calcareous deposits in various devices and in water pipes, the basic titration and the preparation of some of gases in the laboratory…

In this exercise we study some chemical transformations which involve hydrochloric acid.

I- Kinetic Monitoring by a gas volume measurement

The limestone, mainly constituted of calcium carbonate $CaCO_3$, reacts with a solution of the hydrochloric acid according to the equation:

$$CaCO_{3(s)} + 2H_3O^+_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + 3H_2O_{(\ell)}$$

In this first part of the exercise we propose to study the kinetic of this reaction. For that we perform in a balloon, at the date t = 0, the mixture of an amount n_0 of a calcium carbonate $CaCO_{3(s)}$ with an excess of an aqueous solution of the hydrochloric acid $H_3O^+_{(aq)} + Cl^-_{(aq)}$. We obtain a mixture of a volume $V_S = 100\,mL$. The formed carbon dioxide is collected in a graduated test tube. The graph shown in figure 1 represents the variation of the volume $V(CO_2)$ of the cleared carbon dioxide in function of the time.

During the experiment we keep the temperature and the pressure of the cleared gas constant: $T = 25^0\,C = 298\,K$ and $P = 1,02.10^5\,Pa$. We consider the volume of the reaction mixture remains constant.

We assume that the carbon dioxide collected is an ideal gas and we remind that the equation of state of the ideal gas is:

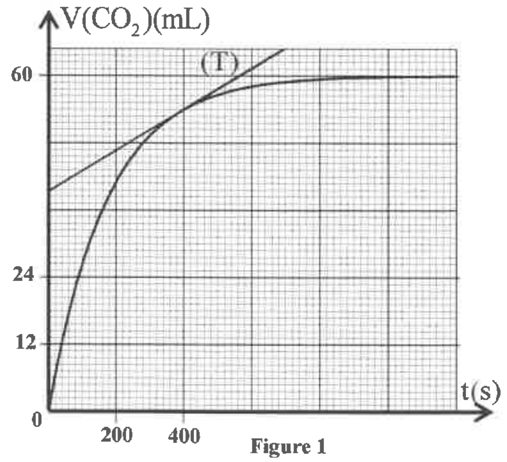


Figure 1

$PV = nRT$. We give the constant of the ideal gas: $R = 8,31\,J.K^{-1}.mol^{-1}$.

1- Using the progress table of the reaction and the equation of state of the ideal gas, show, in the international system of units, that the expression of the progress x of the reaction at a date t is written as: $x = 41,2.V(CO_2)$. **(0,5 pt)**

2- Determine graphically $t_{1/2}$ the half-life of a chemical reaction. **(0,5 pt)**

3- Determine, in the international system of units, the volumetric rate of the reaction, at the instant of date $t_1 = 390\,s$. Line (T) represents the tangent of the curve at the instant t_1. **(0,5 pt)**

II- Titration of an aqueous solution of ammonia by an aqueous solution of hydrochloric acid

In this second part of the exercise, we propose to study, the titration of an aqueous solution of the ammonia NH_3, contained in a detergent, by an aqueous solution of the hydrochloric acid.

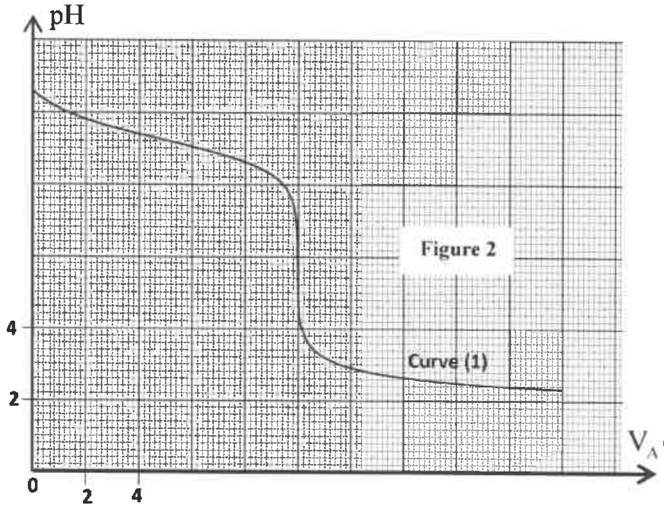
The detergent is concentrated to be titrated. For that, we take a volume of this detergent and we dilute it 100 times, we thus obtain a solution denoted (S_1).

Given: - All measurements are performed at 25^0C;

- The ionic product of water: $K_e = 10^{-14}$;

We titrate a volume $V_B = 20\,mL$ of the solution (S_1), by following the variations of the pH of the reaction mixture in function of the volume V_A poured of an aqueous solution of the hydrochloric acid $H_3O^+_{(aq)} + Cl^-_{(aq)}$ of molar concentration $C_A = 2.10^{-2}\,mol.L^{-1}$.

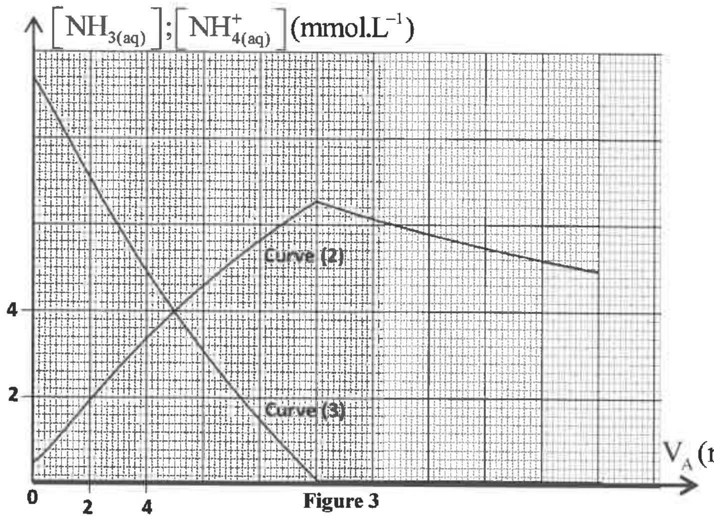
The pH-metric monitoring of the transformation allowed obtaining curve (1) of figure 2. Otherwise, an adapted software allowed obtaining curves (2) and (3) which show the variations of the concentration of the acid species and that of the base species of the pair $NH^+_{4(aq)} / NH_{3(aq)}$ in function of the volume V_A poured (figure 3).



1- Write the chemical equation of the reaction of the titration. **(0,5 pt)**

2- Determine graphically the volume V_{AE} of the aqueous solution of hydrochloric acid poured at the equivalence point. **(0,25 pt)**

3- Show that the molar concentration C_D of the ammonia brought from the detergent is $C_D = 1\,mol.L^{-1}$. **(0,5 pt)**



4- For the previously dosed solution (S_1) :

4-1- Write the chemical equation of the reaction of the ammonia with water. **(0,25 pt)**

4-2- With the help of the curve (1), determine the pH of the solution (S_1). **(0,25 pt)**

4-3- By calculation, determine the molar concentrations $[NH_{3(aq)}]$ and $[NH^+_{4(aq)}]$ in the solution (S_1). **(0,5pt)**

4-4- Deduce the value of the $pK_A(NH^+_{4(aq)} / NH_{3(aq)})$. **(0,5 pt)**

5- Find out again, by using the 3 curves, the value of the $pK_A(NH^+_{4(aq)} / NH_{3(aq)})$ deduced previously. **(0,5 pt)**

6/6-1- Indicate the curve that corresponds to the evolution of $[NH_{3(aq)}]$ with the volume V_A poured. **(0,25 pt)**

6-2- Find out, by using curve (1) and one of the two curves (2) or (3), the molar concentration $[NH_{3(aq)}]$ when the pH of the reaction mixture is $pH = 8,8$. **(0,5 pt)**

III- Electrolysis of an aqueous solution of the hydrochloric acid

We perform the electrolysis of an aqueous solution of the hydrochloric acid $H_3O^+_{(aq)} + Cl^-_{(aq)}$ of volume $V_0 = 500\,mL$ and of molar concentration $C_0 = 5.10^{-2}\,mol.L^{-1}$. For that we use two carbon graphite electrodes linked by a generator of voltage. We observe a release of dihydrogen at one electrode and chlorine at the other electrode.

Given: - The pairs Ox/Red involved in this electrolysis are: $Cl_{2(g)} / Cl^-_{(aq)}$; $H^+_{(aq)} / H_{2(g)}$.

- Faraday constant: $1F = 9,65.10^4\ C.mol^{-1}$,

1- Write the chemical equation occurring at the anode. **(0,5 pt)**

2- Write the overall equation of the reaction of this electrolysis. **(0,5 pt)**

3- From the instant $t = 0$, an electric current of a constant intensity $I = 0,50A$ flows in the electrolysis circuit. Find out the value of the pH of the solution at the instant $t = 30\,min$. **(0,5 pt)**

<u>Exercise 2 :Nuclear transformations (2,5 points)</u>

The combustible of fusion reactions in future nuclear stations is the mixture of the deuterium ^2_1H and the tritium ^3_1H.

We study the formation of the helium ^4_2He from the fusion reaction of the deuterium and the tritium, this nuclear reaction releases also a neutron.

Given: Avogadro constant: $N_A = 6,022.10^{23}\,mol^{-1}$; $1MeV = 1,6022.10^{-13}\,J$.

1- Write the equation of the reaction of this fusion. **(0,25 pt)**

2- From the following statements, how many are accurate? (Give only the number) : **(0,5 pt)**

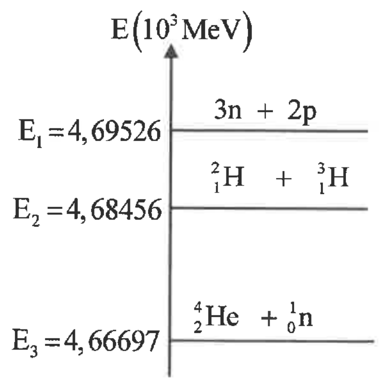
a- The binding energy of a nucleus is equal to the product of the masse defect of the nucleus and the speed of light in the vacuum.

b-The mass of the nucleus is less than the sum of the mass of the nucleons constituting this nucleus.

c-The nuclear fission concerns only the light nuclei whose mass number A<20.

d- The reaction $^8_4Be + ^4_2He \longrightarrow ^{12}_6C$ is a fusion reaction.

e-The nuclear fission is a spontaneous reaction.



3- By using the energy diagram on the right, calculate in MeV unit:

3-1- The binding energy E_ℓ of the nucleus of the helium. **(0,5 pt)**

3-2- The energy released $|\Delta E|$ from this fusion reaction. **(0,5 pt)**

4- Deduce, in MeV unit, the released energy that could be obtained if we perform the fusion reaction of a mole of deuterium nuclei with a mole of tritium nuclei. **(0,25 pt)**

5- The ton of equivalent of petrol (tep) is an energy unit used in industry and economics. It is used to compare the energies obtained from different sources.

The ton of equivalent of petrol (tep) represents $4,2.10^{10}\,J$, which means the released energy on average from the combustion of a ton of petrol.

Suppose n is the number of tons of petrol to burn to obtain an equivalent energy to that released from the fusion of 2 g of deuterium (1 mol) and that of 3g of tritium (1 mol). Find out n. **(0,5 pt)**

Exercise 3 : Electricity (5 points)

The circuits of many electric devices are formed by components such as resistors, capacitors, conductors, diodes …

In this exercise, we propose to study:
- The response of the RC dipole to a step of voltage;
- Free oscillations and forced oscillations in RLC series circuit;
- Reception of a hertzian wave.

1- Charge of a capacitor – Free oscillations in RLC series circuit.

The electric mounting schematized in figure 1 consists of :
- An ideal generator of voltage of e.m.f E .
- Two capacitors of a same capacitance C ;
- A resistor of variable resistance R ;
- An inductor of variable inductance L and a negligible resistance;
- A double switch K;

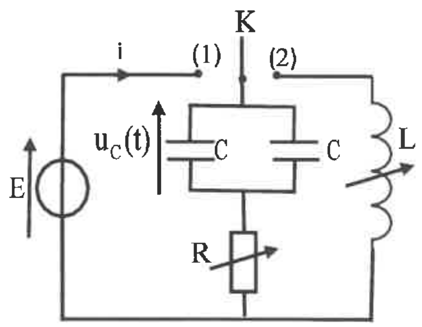


Figure 1

We adjust the value of the resistance to the value $R = R_0 = 1k\Omega$ and we put the switch K at position (1), at an instant chosen as origin of dates $(t = 0)$. A suitable computing system allowed to trace the curve representing the voltage $u_C(t)$ (fig 2). (T) represents the tangent of the curve at the instant t=0.

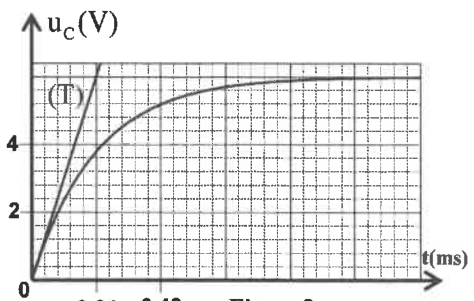


Figure2

1-1-Find out the differential equation for the voltage $u_C(t)$. **(0,5 pt)**

1-2- Determine the value of the current intensity i just after closing the circuit. **(0,25 pt)**

1-3- Check that the value of the capacitance is $C=120\,nF$. **(0,5 pt)**

1-4-When the steady state is reached; we switch the switch K in position (2), at an instant t chosen as a new origin of dates $(t = 0)$.

1-4-1- Find out the differential equation for the charge $q(t)$ of the equivalent capacitor of the two capacitors.**(0,5 pt)**

1-4-2- Establish the expression of the derivative of the total energy E_t of the circuit with respect to time in terms of R_0 and the current intensity i(t) in the circuit, and justify the diminution of E_t during the time. **(0,75 pt)**

2- RLC series oscillator in forced state

We supply a circuit, formed by the inductor, the resistor and one of the two previously capacitors used, by a generator GBF delivering a sinusoidal alternating of adjustable frequency N and constant amplitude $U_m = 100\,V$ (figure 3).

We adjust the inductance L to the value $L_1 = 2,5\,mH$ and the resistance R to the value R_1 .

For frequency N_0, the value of the effective current intensity is maximum: $I_0 \simeq 0,71\,A$.

For frequencies $N_1 = 6,54\,kHz$ and, $N_2 = 12,90\,kHz$ this intensity is : $I_{eff} = 0,50\,A$.

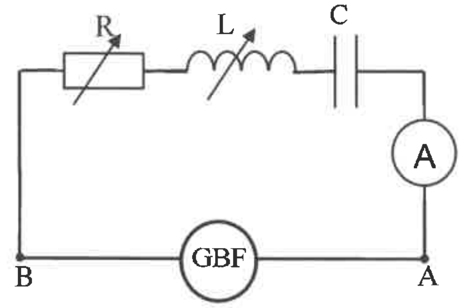


Figure 3

2-1- Determine the frequency N_0 . **(0,5 pt)**

2-2- Check that N_1 and N_2 delineate the bandwidth at -3dB and deduce the value of the quality factor Q. **(0,5 pt)**

2-3- Calculate the value of R_1 . **(0,25 pt)**

2-4- Calculate, at the resonance the value of the average power dissipated by Joule effect. **(0,5 pt)**

3- Reception of a hertzian wave

To receive a hertzian wave, we use the receiving mounting formed by an electronic chain consisted by several stages.

After receiving the modulated signal, we demodulate it by connecting the bung circuit LC with the circuit of a demodulation as shown in figure 4.

3-1- What is the meaning of "demodulate the received signal"? **(0,25 pt)**

3-2-The graphs (1), (2), (3) and (4) of figure 5 represent the voltages displayed with the help of an adequate system:
* u_{PM} by the switches K_1 and K_2 opened ;
* u_{QM} by the switches K_1 and K_2 opened ;
* u_{SM} by K_1 closed and K_2 opened ;
* u_{TM} by the switches K_1 and K_2 closed.

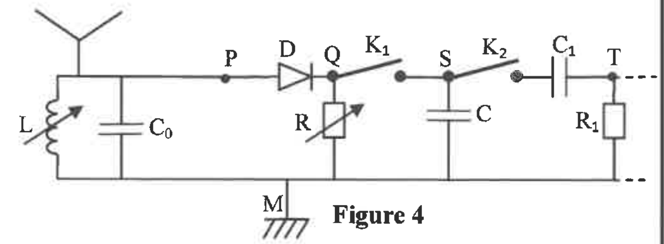


Figure 4

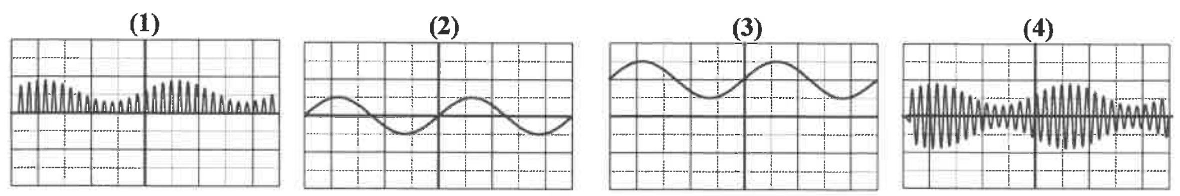


Figure 5

Associate, by justifying, the graph corresponding to u_{QM} and the one corresponding to u_{TM} . **(0,5 pt)**

Exercise 4 : Mechanics (5,5 points)

Parts I and II are independent

Part I : Study of the fall of a ball

In the gravitational field, we give up from a point O, without initial velocity at the instant $t=0$, a small ball (S) of mass m, (figure1).

The ball obeys to two forces:

- Its weight $\vec{P}$;
- The air resistance which is model by the force: $\vec{R}=-\lambda.\vec{v}$, with λ is a positive coefficient and $\vec{v}=v.\vec{k}$ is the velocity vector of the ball.

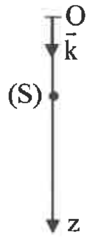


Figure1

We study the motion of the ball in the frame of reference $(O,\vec{k})$ linked to the earth assumed Galilean.

Given : $m=100\,g$; $g=10\,m.s^{-2}$ (the gravitational field strength).

The graph shown in figure 2 represents the evolution, during the time, of the velocity of the ball.

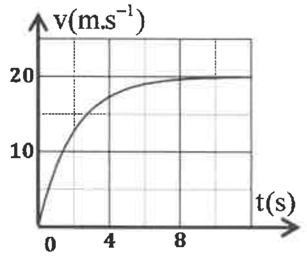


Figure 2

1- Show that the differential equation of the motion of the ball verified by velocity v is written as: $\frac{dv}{dt}+\frac{\lambda}{m}.v=g$. **(0,5 pt)** .

2- Find out the value of λ . **(0,5 pt)**

3- Compare the magnitude of the resistance $\vec{R}$ and that of the weight $\vec{P}$ during the transient state and during the steady state. **(0,5 pt)**

4- We now launch the ball from the point O at the instant $t=0$, vertically down, by a velocity $\vec{V_0}=V_0.\vec{k}$ where $V_0>v_L$ (v_L being the terminal velocity of the motion of the ball)

The solution of the differential equation is written: $v(t)=A+Be^{-\frac{t}{\tau}}$ where A and B are two constants and τ the characteristic time of the motion.

Trace the shape of the curve representing the evolution of the velocity v(t) of the ball during its motion.**(0,5pt)**

Part II: Study of the motion of an oscillator: the gravimeter

A gravimeter is an instrument which allows the measurement of the magnitude of the gravity g with a high precision.

We model a gravimeter by an oscillator constituted by :

- A rod OA of center of inertia G, of mass m and of moment of inertia J_Δ about the horizontal rotation axis through point O. The rod is able to rotate around the axis (Δ) at the vertical plane (Oxy) and its center of inertia G is at the distance $OG=\ell$ from the axis (Δ) (figure3).
- A spiral spring tends to bring back the rod into the vertical position acting on it by couples of moment $M_\Delta=-C.\theta$ about the axis of rotation (Δ) where C is a positive constant and θ is the angle of rotation expressed in radian.

Given: - $m=0,1\,kg$; $\ell=58,4\,cm$;

- $J_\Delta=2,5.10^{-2}\,kg.m^2$; $C=1,4\,N.m.rad^{-1}$

- For small angles: $\cos\theta\approx 1-\frac{\theta^2}{2}$ and $\sin\theta=\theta$ where θ is expressed in radian unit;

- We take : $\pi^2=10$.

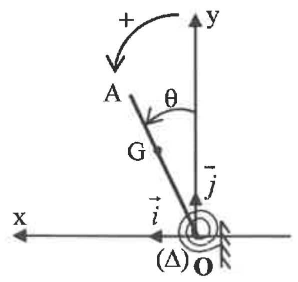


Figure 3

We neglect frictions.

We locate the position of the rod OA at every instant t by its angular displacement θ about its stable equilibrium position.

We move the rod from its vertical equilibrium position with a small angle θ_m in the positive direction and we liberate it without an initial velocity at the instant of date $t=0$.

We study the motion of the oscillator in a frame of reference linked to the earth assumed Galilean.

1- By applying the fundamental relationship of dynamics in the case of rotation; establish the differential equation of the angular displacement θ in the case of small amplitudes. **(0,5 pt)**

2- We choose the position where $\theta=0$ as a reference level of the torsional potential energy ($E_{pt}=0$) and the horizontal plane passes through O as reference level of the gravitational potential energy ($E_{pp}=0$) .

2-1- Show that the expression of the total potential energy of the oscillator $E_p=E_{pp}+E_{pt}$ at an instant t is : $E_p=\frac{1}{2}(C-mg\ell)\theta^2+mg\ell$. **(0,75 pt)**

2-2- By using an energetic study, establish the differential equation of the motion, in the case of small amplitudes. **(0,5 pt)**

2-3-In the case where $C>mg\ell$, the solution of the differential equation is written as:

$$\theta(t)=\theta_m\cos\left(\frac{2\pi}{T_0}t+\varphi\right)$$

2-3-1- Find out the expression of the natural period T_0 in terms of C,m, ℓ, J_Δ and g. **(0,5 pt)**

2-3-2- Calculate g knowing that $T_0=1,1\,s$. **(0,5 pt)**

2-4- The curve shown in figure 4 represents the variation of the total potential energy E_p in function of θ .

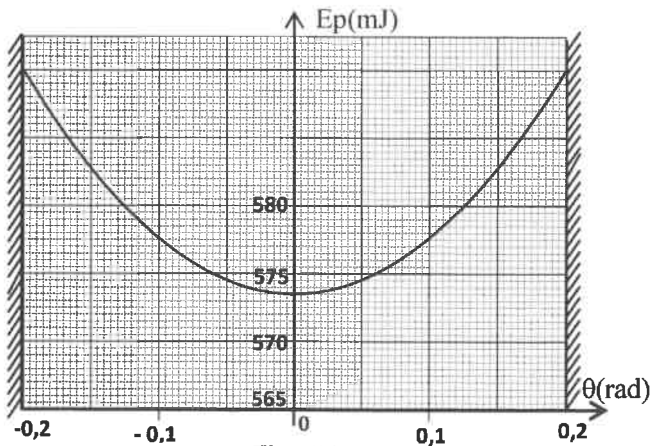


Figure 4

2-4-1- Determine graphically the value of the mechanical energy. **(0,25 pt)**

2-4-2- Find out the absolute value of the angular velocity $\dot{\theta}$ for $\theta=0,125\,rad$. **(0,5 pt)**

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المسالك الدولية – خيار أنجليزية
الدورة العادية 2019
- عناصر الإجابة -

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المركز الوطني للتقويم والامتحانات والتوجيه

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Exercise1 : Chemistry (7 points)

Question	Answer elements	Marking scheme	Reference of the answer in the reference framework
I- 1	Lead to the expression.	0,5	-Draw the progress table ofa reaction and exploit it.
2	Method ; $t_{1/2}=2\,\text{min}$	2x0,25	-Exploitthe different curves of time-evolution of the following: theamount of substance of a chemical specie, its concentration, the progress of a reaction, conductivity, conductance,pressure and volume. -Define the half-life $t_{1/2}$of a chemical reaction. -Determine the half-life $t_{1/2}$ of the chemical reaction graphically or through exploiting the experimental results. -Know the expression of the volume rate of reaction. -Determine graphically the value of the volumetric rate of reaction.
3	Method; $v \approx 1,5.10^{-2}\ \text{mol.m}^{-3}.\text{s}^{-1}$.	2x0,25	
II- 1	Equation of the reaction.	0,5	-Write the equation of titration reaction (useonly one arrow)
2	$V_{AE}=10\,\text{mL}$.	0,25	-Exploit the curve or the results of the titration. -Determine and exploit the point of equivalence.
3	$C_D=100.\frac{C_A.V_{AE}}{V_B}$; $C_D=1\,\text{mol.L}^{-1}$	0,25+0,25	
4-1	Equation of the reaction.	0,25	-Exploit the curve or the results of the titration. -Draw the progress table ofa reaction and exploit it. -Write the equation of the acid-base reaction and identify the two pairs involved. -Determine the pH for an aqueous solution. -Know that the ionic product of water K_W, is the equilibrium constant associated with the equation of the reaction of water autoprotolysis (self-ionization of water).
4-2	$pH=10,6$.	0,25	
4-3	$[NH_{3(aq)}]\simeq 9,6.10^{-3}\ \text{mol.L}^{-1}$, $[NH^{+}_{4(aq)}]\simeq 4.10^{-4}\ \text{mol.L}^{-1}$	0,25 0,25	
4-4	Method $pK_A(NH^{+}_{4(aq)}/NH_{3(aq)})\simeq 9,2$	0,25 0,25	-Write and use the expression of the acid dissociation constantK_A associated with the reaction of an acid with water. -Know the relationship pK_A= -logK_A.
5	Check of $pK_A(NH^{+}_{4(aq)}/NH_{3(aq)})$ by using tree curves.	0,5	
6-1	Curve (3)	0,25	-Exploit the curve or the results of the titration.
6-2	Method ; $[NH_{3(aq)}]=2.10^{-3}\ \text{mol.L}^{-1}$	0,25 0,25	

Question	Answer elements	Marking scheme	Reference of the answer in the reference framework
III-1	Equation of the reaction at the anode	0,5	-Write the half-equationthat occurred in each electrode (use double arrows) and write the overall equation of the reaction during electrolysis (use one arrow).
2	$2Cl^{-}_{(aq)}+2H^{+}_{(aq)}\longrightarrow H_{2(g)}+Cl_{2(g)}$	0,5	
3	Method; $pH=1,5$.	0,25+0,25	--Determine the pH for an aqueous solution. -Establish the relationship between the amount of substance of chemical specieproduced or consumed, the current intensity andthe operating duration of electrolysis. Use this relationship to determine other quantities (quantity of charge, progressof the reaction, changeof the mass, volume of a gas, etc.).

Exercise2 : Nuclear transformations (2,5 points)

Question	Answer elements	Marking scheme	Reference of the answer in the reference framework
1	Equation of the reaction	0,25	Write the equations of nuclear fission and fusion by applying the two laws of conservation.
2	02	0,5	- Define and calculate the mass defect and the binding energy. - Calculate the energy released (produced) by a nuclear reaction: $E_{pro}=\lvert\Delta E\rvert$. - Define the fission and fusion.
3-1	$E_\ell=E_1-E_3=28,29\,\text{MeV}$	0,5	- Define and calculate the mass defect and the binding energy. - Establish the energy balance ΔE of a nuclear reaction using: mass energies and/or binding energies and/or the energy diagram. - Calculate the energy released (produced) by a nuclear reaction: $E_{pro}=\lvert\Delta E\rvert$.
3-2	$\lvert\Delta E\rvert=\lvert E_3-E_2\rvert=17,59\,\text{MeV}$.	0,5	
4	$\lvert\Delta E'\rvert=N_A.\lvert\Delta E\rvert=1,06.10^{25}\ \text{MeV}$	0,25	
5	$n=40,4$	0,5	

Exercise 3 : Electricity (5 points)

Question	Answer elements	Marking scheme	Reference of the answer in the reference framework
1/1-1	Differential equation.	0,5	- Know and exploit the relationship $i=\frac{dq}{dt}$ for a capacitor in receiver convention. - Know and exploit the relationship q = C.u. - Find out the differential equation and verify its solution when the RC dipole is submitted to a step voltage. - Know the capacitance of the equivalent capacitor in series or in parallelassemblies; and recallthe interest of each one - Recognise that the voltage between capacitor terminals is a continuous function of time at t=0, and the current intensity is a discontinuous function at t=0. - Recognise 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.
1-2	$i=6mA$	0,25	
1-3	Check the value of C.	0,5	
1-4-1	Differential equation.	0,5	- Find out the differential equation for the voltage between the capacitor terminals or for its charge $q(t)$ in the damping case. -- Know and exploit the expression of the total energy in the circuit..
1-4-2	Lead to $\frac{dE_t}{dt}=-R_0.i^2$ Justification of the diminution	0,5 0,25	
2/2-1	Method, $N_0 \simeq 9,19\,kHz$	2x0,25	- Recognise the electric resonance phenomenon and its characteristics. -- Know and exploit the impedance expression $Z=\frac{U}{I}$ of a circuit. - Know and exploit the quality factorexpression $Q=\frac{N_0}{\Delta N}$ - Find out and exploit the average power expression $P = U.I.\cos\varphi$
2-2	Check of the boundary ; $Q \simeq 1,4$.	0,25 0,25	
2-3	$R_1 \simeq 99,6\ \Omega$	0,25	
2-4	The expression ; $P \simeq 50\ W$	2x0,25	
3/3-1	Meaning.	0,25	- Exploit the different experimental obtained curves. -Recognise the different stages of amplitude modulation and amplitude demodulation through their corresponding assembly schemes. -Know the role of different used filters. - Know the stages of demodulation - Recognise the essential components required to assemble an AM radio, and their roles in the demodulation.
3-2	(1)------ u_{QM} ; (2)---- u_{TM}	2x0,25	

Exercise 4 : Mechanics (5,5 points)

	Question	Answer elements	Marking scheme	Reference of the answer in the reference framework
Part I	1	Demonstration	0,5	-Apply Newton's second law to find outthe differential equation of a solid's centre of inertia motion in frictional vertical fall.
	2	$\lambda=\frac{m.g}{v_L}$; $\lambda=5.10^{-2}$ SI .	2x0,25	-Exploit the curve $v_G=f(t)$ to determine: * theterminal speed; * the characteristic time τ ; * the initial state and the steady state
	3	- Transient state : P>R ; - Steady state: P=R .	0,25 0,25	
	4	Appearance of the curve	0,5	
Part II	1	Lead to the differential equation.	0,5	-Know and apply the fundamental relationship of dynamics in the case of rotation around a fixed axis in order to establish the differential equation of the motion, and solve it.
	2/2-1	Lead to the requested expression.	0,75	-Know and exploit the expression of the torsional potential energy. - Exploit the conservation and the non-conservation of the mechanical energy of the torsional pendulum. -Exploit the conservation of the mechanical energy of a physical pendulum in the small oscillations case.
	2-2	$\ddot{\theta}+\frac{C-mg\ell}{J_\Delta}\theta=0$.	0,5	
	2-3-1	Lead to $T_0=2\pi\sqrt{\frac{J_\Delta}{C-mg\ell}}$	0,5	-- Establish the expression of the natural period of the torsional pendulum. -Establish the expression of the natural period for the physical pendulum.
	2-3-2	$g=9,82\,m.s^{-2}$.	0,5	
	2-4-1	$E_m=0,59\,J$	0,25	-Exploit the energy diagrams. -Exploit the conservation of the mechanical energy of a physical pendulum in the small oscillations case. -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. - Know and exploit the expression of the mechanical energy of a torsional pendulum.
	2-4-2	Method; $\left\lvert\dot{\theta}\right\rvert \simeq 0,9\,rad.s^{-1}$.	2x0,25	