الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2019 RS27E
-الموضوع-

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
المركز الوطني للتقويم والامتحانات والتوجيه

3	مدة الإنجاز	الفيزياء والكيمياء	المادة
5	المعامل	شعبة العلوم التجريبية: مسلك علوم الحياة والأرض – خيار أنجليزية	الشعبة أو المسلك

- **programmable scientific calculator is not allowed.**
- **Give the literal expressions before every numerical application.**

This exam paper consists of four exercises: one in chemistry and three in physics.

Chemistry (7 points)	• **Study of a chemical system - Titration of a fertilizer** • **Study of a battery**	**7 points**
Physics (13 points)	**Exercise 1 :** • **Light waves**	**3 points**
	Exercise 2 : • **RL dipole** • **RLC series circuit**	**5 points**
	Exercise 3 : Free fall – Oscillating system • **Free fall of a ball** • **Oscillating system { solid – spring}**	**5 points**

scale	Subject

Chemistry (7 points)

The acid-base and redox reactions are chemical transformations that involves acid/base and ox/red pairs. They are usually utilized to determine the parameters and explain the functioning of the chemical system.

The two parts are independents

Part 1: Study of a chemical system – Titration of a fertilizer

The ammonia of formula NH_3 is a gas that dissolves in water to give an aqueous solution that has basic properties. Ammonia solutions are sold in markets as cleansers and stain removers. The conjugate acid of ammonia is NH_4^+ may be obtained by dissolving some nitrogen products as fertilizers in water.

1. Study of a chemical system at equilibrium

Consider an aqueous solution (S_0) of ammonia NH_3, of volume V_0 and molar concentration $C_0 = 1,0.10^{-2}\ mol.L^{-1}$. The pH of this solution is $pH = 10,6$ at $25°C$.

The equation of reaction modelling the transformation between ammonia and water is:

$$NH_{3(aq)} + H_2O_{(\ell)} \rightleftharpoons NH_{4(aq)}^+ + HO_{(aq)}^-$$

Data: The ionic product of water at $25°C$: $K_e = 10^{-14}$

0,75 **1.1** Show that the effective molar concentration of the ammonium ions $NH_{4(aq)}^+$ at the equilibrium state is given by the relation: $\left[NH_{4(aq)}^+\right]_{éq} = \dfrac{K_e}{10^{-pH}}$ Calculate its value.

1 **1.2** Calculate the value of the reaction quotient $Q_{r,éq}$ of the chemical system at equilibrium. Deduce the value of the equilibrium constant K related to the equation of reaction.

0,5 **1.3** The constant of acidity of the pair $(NH_{4(aq)}^+ / NH_{3(aq)})$ is expressed by: $K_A = \dfrac{K_e}{K}$. Calculate pK_A of this pair.

0,5 **1.4** We mix a volume of the solution of ammonia (S_0) with a volume of a solution of ammonium chloride $NH_{4(aq)}^+ + Cl_{(aq)}^-$. The pH of the mixture is $pH = 6,2$.

Draw the predominance diagram of the species of the pair $(NH_{4(aq)}^+ / NH_{3(aq)})$. Deduce the predominant species in the mixture.

2. Titration of a fertilizer

The ammonium nitrate NH_4NO_3 is an ionic compound present in several fertilizers. A fertilizer bag has the following indication: **"Mass percentage of ammonium nitrate is 75%"**.

To verify the mass percentage of ammonium nitrate indicated by the producer, we prepare a solution (S_A) by dissolving the mass $m = 15,0\ g$ of the fertilizer in a volume $V_0 = 1,0\ L$ of distillate water.

We titrate the ammonium ions $NH_{4(aq)}^+$ present in a volume $V_A = 10,0\ mL$ of the solution (S_A) by an aqueous solution (S_B) of sodium hydroxide $Na_{(aq)}^+ + HO_{(aq)}^-$ of molar concentration $C_B = 0,10\ mol.L^{-1}$.

The volume of (S_B) poured at equivalence is $V_{B,E} = 14,0\ mL$.

Data: $M(NH_4NO_3) = 80,0\ g.mol^{-1}$.

0,5 **2.1** Write the equation of reaction between ammonium ions $NH^+_{4(aq)}$ and hydroxide ions $HO^-_{(aq)}$ during the titration, knowing that it is total.

0,75 **2.2** Determine the value of the molar concentration C_A of the ammonium ions $NH^+_{4(aq)}$ in the solution (S_A).

0,75 **2.3** The mass percentage of ammonium nitrate contained in this fertilizer is expressed by: $\frac{m(NH_4NO_3)}{m}$, where m is the fertilizer mass.

Calculate the mass percentage of ammonium nitrate contained in this fertilizer. Compare it to the value announced by the producer.

Part 2: Study of a battery.

A battery involves the redox couples $Ni^{2+}_{(aq)} / Ni_{(s)}$ and $Cu^{2+}_{(aq)} / Cu_{(s)}$. Its cell diagram (shorthand notation) is: $(-)\ Ni_{(s)} \left| Ni^{2+}_{(aq)} \right\| Cu^{2+}_{(aq)} \left| Cu_{(s)} \right. (+)$.

The initial amount of matter of cooper II ions is equal to $n_i(Cu^{2+}_{(aq)}) = 1,0.10^{-2}\ mol$ and $Ni_{(s)}$ is in excess.

The current intensity debited by the battery is $I = 40\ mA$ during all its working duration.

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

0,75 **1.** Write the equation of reaction at the functioning of the battery.

1 **2.** Calculate Q_{max} the maximal amount of electricity (Maximal charge) debited by the battery.

0,5 **3.** Determine the lifetime Δt of this battery.

Physics (13 points)

Exercise 1 (3 points): Light waves

Human eyes cannot perceive just some radiations of visible domain, of frequencies between $7,5.10^{14}\ Hz$ and $3,0.10^{14}\ Hz$. The propagation of light in some homogeneous transparent mediums can engender some physical phenomena and provide information on the nature of light and the properties of the medium.

1. A source of light produces a parallel beam composed of two radiations, blue and red, of wavelengths λ_{0R} and λ_{0B}.

Data: Light celerity in vacuum: $c = 3.10^8\ m.s^{-1}$; $\lambda_{0B} = 487,6\ nm$; The velocity of propagation of the blue radiation through the prism of glass is $v_B = 1,80.10^8\ m.s^{-1}$.

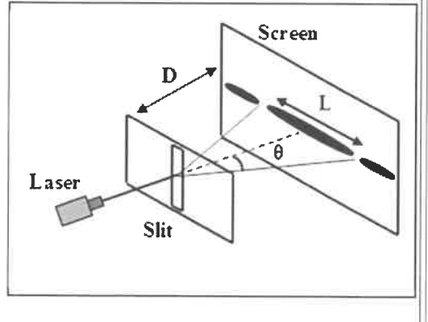
0,75 **1.1** Calculate the frequency ν_{0B} of the blue radiation. Is it observable for the human eyes? Justify.

1.2 The previous source release a parallel light beam composed of two radiations on a prism of glass.

0,5 **1.2.1** Calculate v_R the velocity of propagation of the red radiation in the prism, knowing that the refraction index of glass for the red radiation is $n_R = 1,612$.

0,5 **1.2.2** What is the property of the prism? Justify.

2. The monochromatic radiation, of wavelength $\lambda = 487,6\ nm$, arrives to a vertical slit, of width a. We place a screen in a distance $D = 2m$ of the slit, we observe the pattern in the figure beside.



0,25 **2.1** Give the name of the observed phenomenon in the figure.

0,75 **2.2** Show that the length of central spot is written as: $L = \frac{2\lambda D}{a}$. (Take $\tan\theta \approx \theta(rad)$).

0,25 **2.3** Calculate the width of the split a, knowing that $L = 3,6\ cm$.

Exercise 2 (5 points): RL dipole – RLC series circuit

The behaviour of some electric or electronic circuits depends on the nature of the components present in these circuits. This engenders different phenomena like the charge and the discharge of a capacitor, the establishment or the breaking off of the current in a coil and the electric oscillations. These phenomena may be influenced by the modification of some parameters.
This exercise aims to the study of the influence of the circuit resistance on:
- **The response of RL dipole.**
- **The electric oscillations in RLC series circuit.**

1. Influence of the resistance on the response of RL dipole

The assembly presented in figure (1) is composed of:
- A generator of electromotive force $E = 6V$;
- A coil $(L = 0,1H ; r = 0)$;
- An ohmic conductor of adjustable resistance R;
- A switch K.

We adjust the resistance on the value $R = 220\Omega$ and we turn on the switch at $t_0 = 0$.

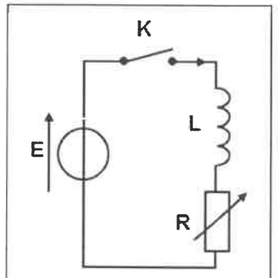


Figure (1)

0,5 **1.1** Recopy the schema of figure (1) and represent the voltage u_L in the terminals of the coil and u_R in the terminals of the ohmic conductor in receiver convention.
Indicate in the same schema the assembly of the oscilloscope to visualize the voltage u_R.

0,5 **1.2** Show that the differential equation of the intensity of the current $i(t)$ is: $\frac{di}{dt} + \frac{R}{L}.i = \frac{E}{L}$

1,25 **1.3** The solution of this differential equation is: $i(t) = \frac{E}{R}.\left(1 - e^{-\frac{t}{\tau}}\right)$.

Using the solution, find the expression and the value of:
a. Time constant τ of this circuit.
b. Current intensity I_0 at the permanent state.

0,5 **1.4** Calculate the magnetic energy $\mathscr{E}_m$ stored by the coil in the permanent state.

0,5 **1.5** We adjust again the resistance of the ohmic conductor to the value $R' = 2R$. The new time constant is τ'.
Compare τ' and τ. Deduce the effect of the resistance R on the establishment of the current in RL dipole.

2. The influence of the circuit resistance on electric oscillations in RLC series circuit.

The assembly of figure (2) is constituted of a generator of electromotive force $E = 6V$, a coil $(L = 0,1H\ ; r = 0)$, an ohmic conductor of adjustable resistance R, a capacitor of capacity C and a switch K.
We charge the capacitor, then at $t_0 = 0$ we switch to the position (2).
The curves (1), (2) and (3) in figure (3) (page 5/6) represent the voltage $u_C(t)$ on the terminals of the capacitor for three values of R:
$R_1 = 0$, $R_2 = 20\Omega$, $R_3 = 200\Omega$.

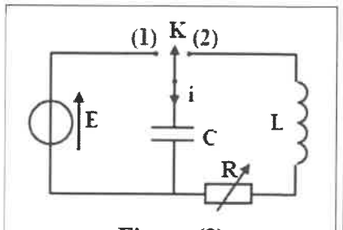


Figure (2)

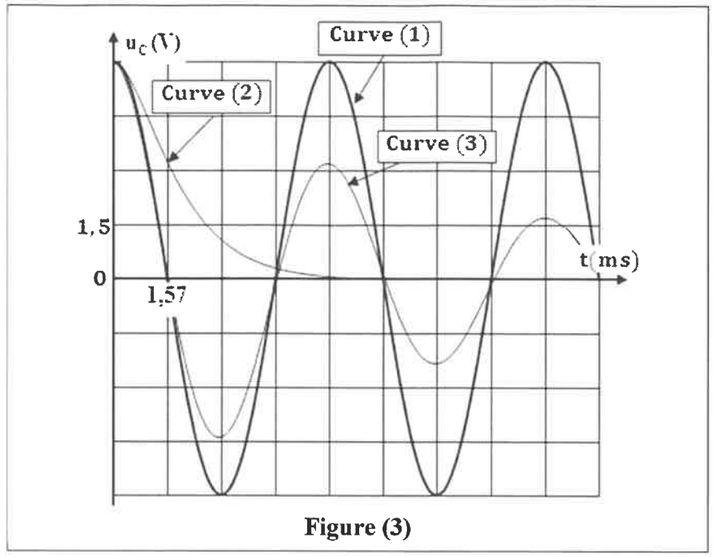


Figure (3)

0,5 **2.1** Refer every curve of figure (3) to the adequate resistance.
0,25 **2.2** Deduce the influence of the resistance on the oscillation in RLC series circuit.
1 **2.3** Exploit curve (1):
a. Determine the capacity C of the capacitor.
b. Calculate the total energy $\mathscr{E}$ of the circuit.

Exercise 3: (5 points) Free fall – oscillating system { solid – spring}

The motion of the mechanic systems depends on the nature of mechanical actions applied to them. The study of time evolution of these systems permit to determine some dynamic and kinetic magnitudes and explain some energetic aspects.
This exercise aims to:
- **Study the free-fall of a ball.**
- **Study an oscillating system {solid-spring}.**

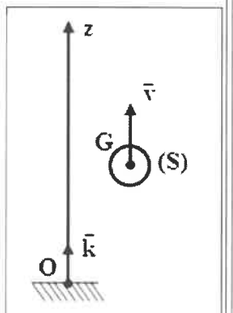


Figure (1)

Part 1: Study the free-fall of a ball.

We throw a ball (S), of mass m, vertically to the top at an instant $(t_0 = 0)$ with an initial velocity $\vec{v}_0$.
We study the free-fall motion of the ball in a frame of reference $(O,\vec{k})$ linked to Earth and assumed Galilean (figure1).
We coordinate the position of the centre of inertia G of the ball at an instant t by the ordinate z_G in this frame of reference.

0,5 **1.** Applying Newton's second law, show that the differential equation of the ordinate z_G is written as:
$\frac{d^2 z_G}{dt^2} = -g$
0,5 **2.** What is the nature of motion of G during rising phase? Justify.
3. The kinetic equation of motion of G is: $z_G = -5t^2 + 2t + 1,5$ (m)
0,5 **3.1** Determine the value of z_0 and v_0 at $(t_0 = 0)$.
0,5 **3.2** What is the instant when the velocity is zero?

Part2: Study of an oscillating system {solid-spring}

The previous ball (S) is attached to the end of a spring of a non-joined turns, of a horizontal axis, of neglected mass and stiffness K. The ball may slide in a horizontal rail (Figure (2)).
We study the motion of the centre of inertia G of the ball (S) in a frame of reference $(O,\vec{i})$ linked to Earth and assumed Galilean.
We locate the position of G at an instant t in this frame by its abscissa x. At equilibrium $x_G = x_0 = 0$.

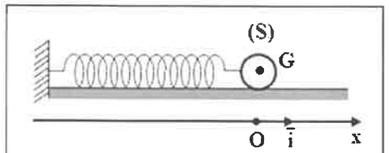


Figure (2)

Data: $m = 0,24\,kg$; $\pi^2 = 10$; Frictions are neglected.

We remove away (S) from its equilibrium position by a distance X_m and we release it without initial velocity.
1. An experimental study permit to obtain the curve in figure (3) representing the variations of the acceleration $\ddot{x}(t)$ of motion of G.

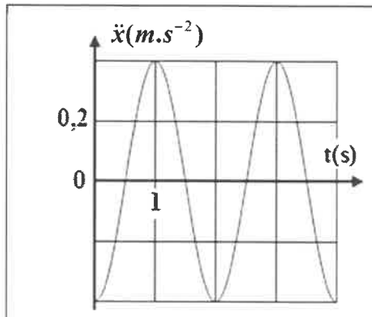


Figure (3)

0,5 **1.1** Applying Newton's second law, establish the differential equation of the abscissa x.
1.2 The solution of this differential equation is:
$x(t) = X_m.\cos\left(\frac{2\pi}{T_0}.t\right)$
0,5 **1.2.1** Find, in terms of the useful parameters, the expression of the acceleration $\ddot{x}(t)$.
0,75 **1.2.2** Exploit the curve of figure (3) and determine the values of T_0 and X_m.
0,5 **1.2.3** Deduce the value of stiffness K.
0,75 **2.** Determine the instants, in the interval $[0;3s]$, when the velocity is maximal. Calculate its value.