# الامتحان الوطني الموحد للبكالوريا
## المسالك الدولية
الدورة العادية 2020
- الموضوع –

SSSSSSSSSSSSSSSSSS | NS 28E

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

| | | | |
|---|---|---|---|
| المادة | الفيزياء والكيمياء | مدة الإنجاز | 3 |
| الشعبة أو المسلك | شعبة العلوم التجريبية مسلك العلوم الفيزيائية (خيارإنجليزية) | المعامل | 7 |

The use of a non-programmable scientific calculator is allowed

Literal expressions should be given before doing numerical calculations

This exam paper consists of five exercises

## EXERCISE 1 (7 points)

- Study of the aqueous solution of ammonia
- Study of the electrochemical cell of silver-chromium

## EXERCISE 2 (3 points)

- Propagation of waves.

## EXERCISE 3 (2,5 points)

- Disintegration of the polonium 210.

## EXERCISE 4 (5 points)

- Response of RL dipole to a step voltage.
- Study of damping and maintaining oscillations in a RLC series circuit

## EXERCISE 5 (2,5 points)

- Study of the vertical falling motion of a ball in a viscous liquid

Marking scale

## EXERCISE 1 (7 points)

**Part 1 and part 2 are independent**

### Part 1 : Study of the aqueous solution of ammonia

*Ammonia $NH_3$ is a gas which dissolves in water to give a basic aqueous solution of ammonia. Some commercial aqueous solutions of ammonia can be used, after dilution, as cleaning products.*

In this part, we propose studying the aqueous solution of ammonia.

An aqueous solution $S_b$ of ammonia of volume V can be made by diluting 100 times a commercial solution $S_0$ of concentration $C_0$.

**Given :**

- All measurements are made at 25°C ;
- The ionic product of water $K_w = 10^{-14}$.

**1. Titration of the solution $S_b$**

We carry out the pH-metric titration of a volume $V_b$ = 15 mL of the solution $S_b$ of concentration $C_b$ by using 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 1 shows the pH changes of the mixture as a function of the volume $V_a$ added of $S_a$. ( $pH = f(V_a)$ ).

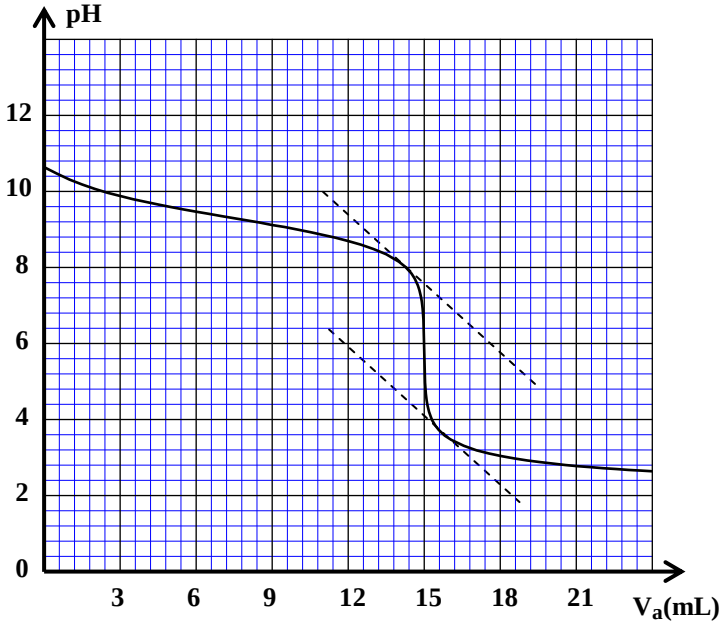



**Figure 1**

**0,5** **1.1.** Write the reaction equation of this titration.

**0,5** **1.2.** Write at equivalence point the relationship between $C_b$, $C_a$, $V_b$ and $V_{aE}$ which is the volume added of the solution $S_a$ at equivalence point.

**0,5** **1.3.** Show that the concentration $C_b$ is $C_b = 10^{-2}mol.L^{-1}$ then deduce the value of $C_0$.

**0,5** **1.4.** Choose from the following acid-base indicators the appropriate one for this titration. Justify your answer.

| **Indicator** | Methyl orange | Methyl red | Phenolphtalein |
|---|---|---|---|
| **pH-range** | 3,1 – 4,4 | 4,2 – 6,2 | 8,2 – 10 |

**2. Study of the solution $S_b$**

The measurement of the pH of the aqueous solution $S_b$ gives pH = 10,6.

**0,5** **2.1.** Write the reaction equation of the ammonia with water.

**0,75** **2.2.** Calculate the effective molar concentration of the hydroxide ions $HO^-$ in the solution $S_b$.

**0,5** **2.3.** Calculate the final progress rate $\tau$ of this reaction.

**0,5** **2.4.** Check that the reaction quotient at equilibrium is $Q_{r,éq} = 1{,}65.10^{-5}$.

**0,5** **2.5.** Deduce the value of $pK_A$ of the pair $NH_4^+/NH_3$.

**Part 2 : Study of the electrochemical cell silver-chromium**

*In this part, we propose studying an electrochemical cell.*

This electrochemical cell consists of :

- an electrode of chromium (Cr) immersed in the aqueous solution of the chromium (III) nitrate $Cr^{3+}_{(aq)} + 3NO^{-}_{3(aq)}$ ;
- an electrode of silver (Ag) immersed in the aqueous solution of the silver nitrate $Ag^{+}_{(aq)} + NO^{-}_{3(aq)}$ ;
- a salt bridge connects these two solutions.

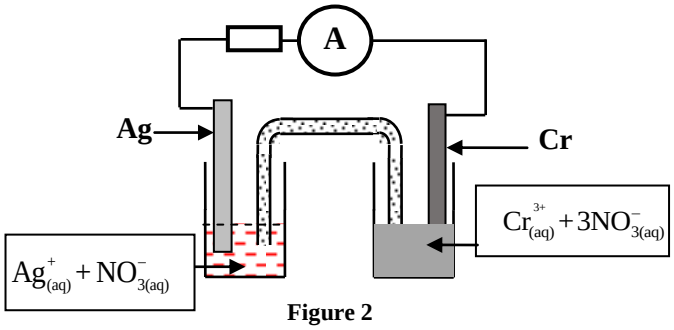



**Figure 2**

In series a resistor and an ammeter are connected between terminals of the electrochemical cell (figure 2). The ammeter indicates the flow of an electric current of constant intensity through the circuit.

After a period of time $\Delta t$ of the functioning of the electrochemical cell, we observe a deposit on the silver electrode but the chromium electrode decreases in mass.

**Given :**

- The molar mass of the chromium is M(Cr) = 52 $g.mol^{-1}$;
- 1F= 96500 $C.mol^{-1}$.

**0,5** **1.** Determine the anode of this electrochemical cell. Justify.

**0,5** **2.** Represent the cell diagram of this electrochemical cell.

**0,75** **3.** Write half-equations at electrodes and the overall equation during the functioning of this electrochemical cell.

**0,5** **4.** Knowing that the quantity of charge transferred by this electrochemical cell during the period of time $\Delta t$ is $Q = 5,79C$, calculate the change in mass $\Delta m$ of the chromium electrode.

## EXERCISE 2 (3 points)

**Propogation of waves**

**I - Copy on your answer sheet the number of the question and write the letter of the correct answer from the suggested statements.**

**0,25** **1.** During the propagation of a mechanical wave there is

| | | | |
|---|---|---|---|
| **A** | transport of matter and no transfer of energy. | **C** | no transport of matter and no transfer of energy. |
| **B** | no transport of matter and transfer of energy. | **D** | transport of matter and transfer of energy. |

**0,25** **2.** A mechanical wave is called transverse when

| | | | |
|---|---|---|---|
| **A** | the direction of the disturbance is the same as the direction of the propagation. | **C** | the direction of the disturbance is perpendicular to the direction of the propagation. |
| **B** | it propagates in the vacuum. | **D** | the propation is done without damping. |

**0,25** **3.** A sound wave is

| | | | |
|---|---|---|---|
| **A** | an electromagnetic wave. | **C** | a longitudinal mechanical wave. |
| **B** | a tansverse mechanical wave. | **D** | a wave that travels in vacuum. |

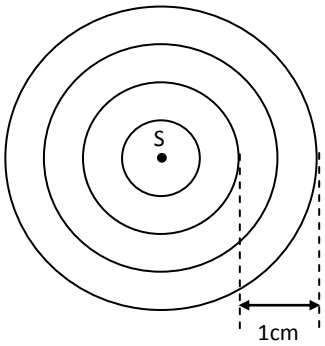
0,25 **4.** During the diffraction of a wave,

| | | | |
|---|---|---|---|
| **A** | there is a change in the frequency. | **C** | there is a change in the wave speed. |
| **B** | there is a change in the wavelength. | **D** | there are no changes in the frequency, in the wavelength and in the wave speed. |

0,25 **5-** We consider a point M from the surface of the water where a progressive wave propagates. This point M repeats the same motion of the source S with a time delay $\tau$.
The relationship between the elongation of M and the elongation of S is:

| | | | |
|---|---|---|---|
| **A** | $y_M(t) = y_s(t+\tau)$ | **C** | $y_M(t) = y_s(t+2\tau)$ |
| **B** | $y_M(t) = y_s(t-2\tau)$ | **D** | $y_M(t) = y_s(t-\tau)$ |

**II –**The source S of a vibrator produces a sinusoidal progressive wave of frequency N across the surface of the water.
The wave propagates without damping and without reflection with a wave speed $v = 0{,}25 m.s^{-1}$.
The figure on the right represents the aspect of the surface of the water at an instant $t_1$.
The circular ripples illustrates crests.




0,5 **1-**By exploiting the figure on the right, determine the value of the wavelength $\lambda$ .

0,5 **2-**Find the value of the frequency N of this wave.

0,75 **3-**We consider a point M far from S by d = 5cm. Calculate the time delay $\tau$ between motions of S and M.

## EXERCISE 3 (2,5 points)

**Disintegration of the polonium 210**

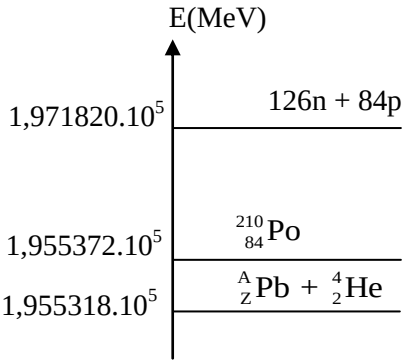
The polonium is a rare radioactive metal which was discovered by the scientist Pierre Curie in 1898.
This metal of symbol Po and atomic number 84 is radioactive. Polonium 210 is the only isotope existing in nature. A nucleus of polonium 210 decays into a nucleus of lead ${}^{A}_{Z}Pb$ by the emission of an $\alpha$-particle.

**Given :**

- The half-life of the polonium 210 is $t_{1/2} = 138$ days;
- $1u = 931{,}41\ MeV/c^2$ ; $1\ u = 1{,}66\ 10^{-27}$ kg.

0,5 **1-**Write the equation of the disintegration of the polonium 210 by determining A and Z.

**2-**By using the energy diagram on the right, calculate:




0,5 **2-1-**the energy released (produced) $E_{pro}$ during the disintegration of the polonium 210 nucleus.

0,5 **2-2-**in kilogrammes (kg), the mass defect $\Delta m$ of the polonium 210 nucleus.

0,5 **3-** Calculate in $s^{-1}$ the decay constant $\lambda$ of the polonium 210.

0,5 **4-**At t=0, the activity of a sample of Polonium 210 nuclei is $a_0 = 3{,}5.10^{11}$ Bq.
Determine, in days, the instant of time $t_1$when the activity of this sample will be $a_1 = 3{,}7.10^4$Bq.

## EXERCISE 4 (5 points)

*Many electric and electronic devices are made of capacitors and inductors as essential components.*

This exercise aims at studying:
- the response of RL dipole to a step voltage.
- the discharging of a capacitor in a RL dipole
- the maintaining of oscillations in a RLC series circuit

**I- The response of RL dipole to a step voltage.**

We build the set-up sketched in figure 1.

This set-up includes :
- an inductor of inductance L and of resistance r ;
- a resistor of resistance $R = 90\,\Omega$ ;
- a generator of electromotive force E et and of negligible internal resistance;
- a switch K.

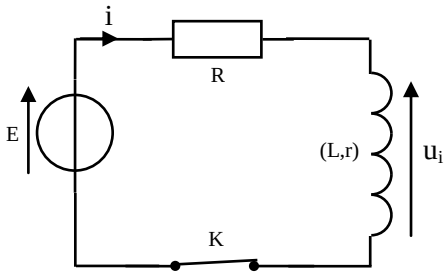
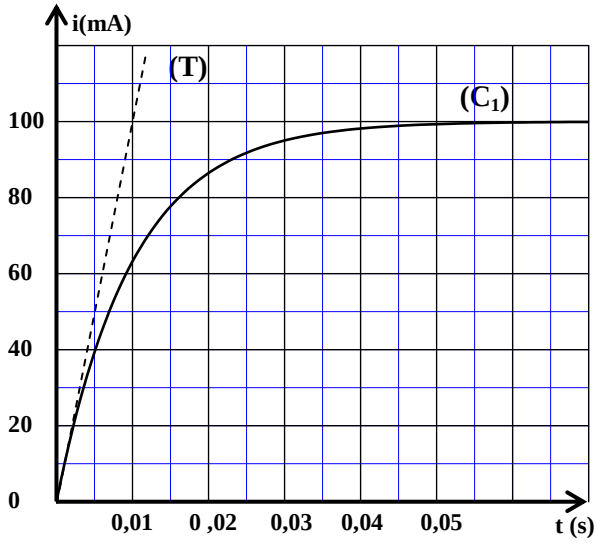



**Figure 1**

We switch on the circuit at an instant of time t = 0.

A datalogger leads to visualize curves ($C_1$) and ($C_2$) which represent successively the evolution of the intensity of the electric current i(t) and the evolution of the voltage $u_i(t)$ between terminals of the inductor.

The line (T) represents the tangent of the curve ($C_1$) at t = 0 (figure 2).



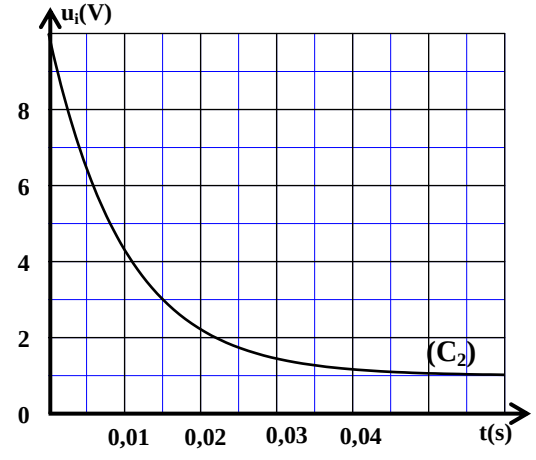




**Figure 2**

**0,5** **1**-Show that the differential equation verified by the intensity of the electric current i(t) is written as : $\frac{di}{dt}+\frac{R+r}{L}.i=\frac{E}{L}$.

**0,5** **2**-By exploiting curves ($C_1$) and ($C_2$) in their both steady states, determine the value of r.

**0,5** **3**- Check that L = 1H.

## II - Discharging a capacitor in a RL dipole

At an instant taken as origin ot time t=0, in series with the previous inductor and a resistor of resistance $R = 90\,\Omega$, we connect a fully charged capacitor of capacitance C (figure 3).
The curve in figure 4 gives the evolution of the voltage $u_C(t)$ between terminals of the capacitor.

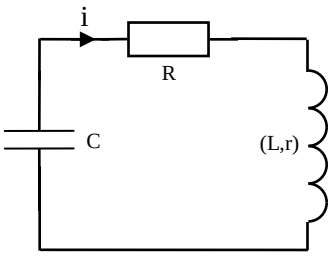


**Figure 3**

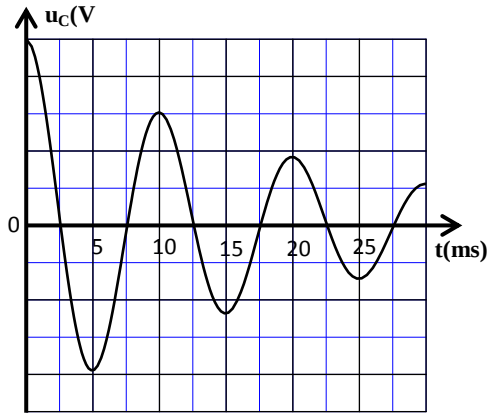


**Figure 4**

**0,25** **1**-Which state of oscillations is shown in figure 4 ?

**0,5** **2**-Find out the differential equation verified by the voltage $u_C(t)$.

**0,5** **3**- Calculate the value of the capacitance C of the capacitor by assuming that the pseudo-period is equal to the natural period. We take $\pi^2 = 10$.

## III -Maintaining oscillations in a RLC series circuit

To maintain the oscillations in the previous circuit of the figure 3, we connect in series a generator G providing the circuit by a voltage which is proportional to the intensity of the electric current as $u_G(t) = k.i(t)$ (Fig. 5).
The curve in figure 6 shows the evolution of the intensity i(t) in the circuit where $k = k_0$.

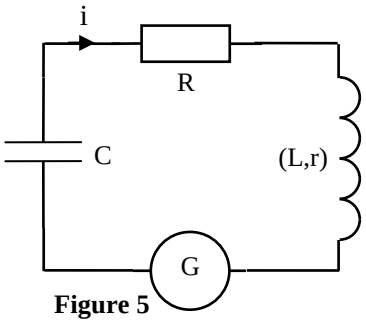


**Figure 5**

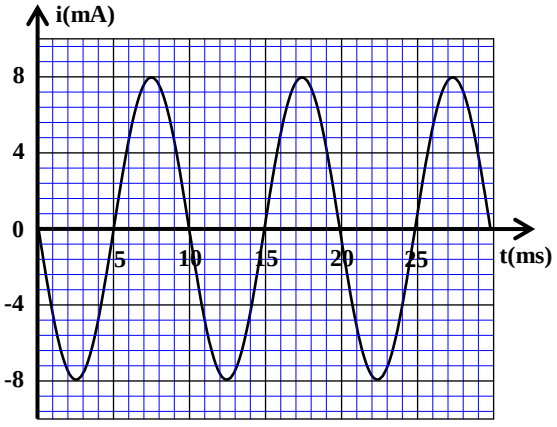


**Figure 6**

**0,5** **1**-Determine the value of $k_0$.

**0,75** **2** –Knowing that the expression of the intensity i(t) in the circuit is written as :

$$i(t) = I_m \cos\left(\frac{2\pi}{T_0}.t+\varphi\right)$$

Determine the values of $I_m$, $T_0$ and $\varphi$.

**0,5** **3**-Calculate the total energy $E_t$ of the circuit.

**0,5** **4**-Find the value of the electric energy $E_{e1}$ stored in the capacitor at the instant $t_1 = 16\,ms$.

## EXERCISE 5 (2,5 points)

**Study of the vertical falling motion of a ball in a viscous liquid**

*We suggest studying the vertical falling motion with friction in a viscous liquid of a homogeneous ball of mass m.*

By using a camera and an appropriate software, we monitor the evolution of the velocity of G the center inertia of the ball during its falling through the viscous liquid.

We study the motion of G in a frame of reference assumed Galilean.

We locate the position of G at an instant t of time by its ordinate y on the downward y-axis $(O, \vec{j})$ (figure1).

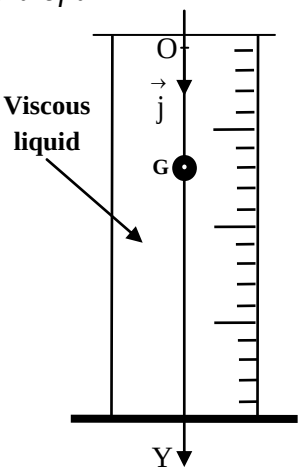


**Figure 1**

We model the viscous frictional forces by $\vec{f} = -kv.\vec{j}$ where v is the velocity of G at an instant t and k is a positive constant.

The upthrust force (Archimedes's force) is negligible to other forces.

**Given:**

- The strength of the gravitational field is $g = 10\,m.s^{-2}$ ;

- $m = 2,5.10^{-2}\ kg$ .

**0,5** **1-** By applying Newton's second law on the ball, show that the differential equation verified by the velocity v of the center inertia G is $\frac{dv}{dt} + \frac{k}{m}v = g$ .

**0,25** **2-** Find out the expression of the terminal velocity $v_l$ of G in terms of g, m and k.

**0,25** **3-** The curve in figure 2 represents the evolution of the velocity v of the center of inertia G of the ball.

Determine graphically the value of $v_\ell$ .

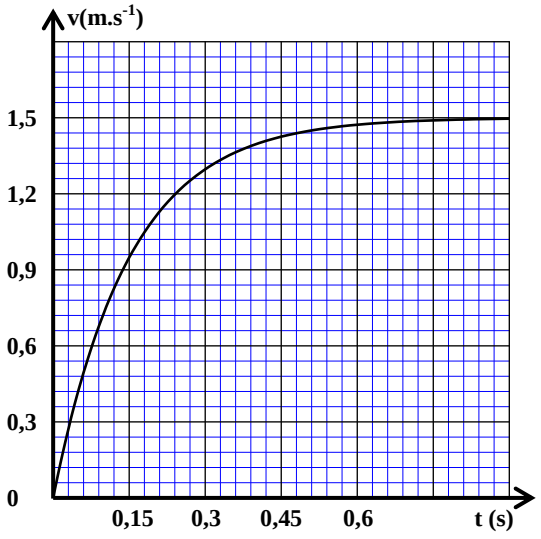


**Figure 2**

**0,5** **4-** Verify, in the international units, that the differential equation of the motion of G is written as:

$$\frac{dv}{dt} = 10 - 6,67\,v$$

**5-** By using Euler's method and the data of the following table, calculate:

**0,5** **5.1.** the acceleration $a_1$ at the instant $t_1$.

**0,5** **5.2.** the velocity $v_3$ at the instant $t_3$ knowing that the step of calculating is $\Delta t = 0,015s$ .

| t | v (m.s$^{-1}$) | a (m.s$^{-2}$) |
|---|---|---|
| / | / | / |
| $t_1$ | 0,150 | $a_1 = ....$ |
| $t_2$ | 0,285 | 8,10 |
| $t_3$ | $v_3 = ...$ | / |

# الامتحان الوطني الموحد للبكالوريا
## المسالك الدولية
الدورة الاستدراكية 2020
- عناصر الإجابة –

SSSSSSSSSSSSSSSSSS | RR 28E

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

| | | | |
|---|---|---|---|
| المادة | الفيزياء والكيمياء | مدة الإنجاز | 3 |
| الشعبة أو المسلك | شعبة العلوم التجريبية مسلك العلوم الفيزيائية (خيار إنجليزية) | المعامل | 7 |

## Exercise 1 (7 points)

| Question | | Answers | Marking scale | Question reference in the framework |
|---|---|---|---|---|
| Part 1 | I-1. | $CH_3COO^-_{(aq)} + H_2O_{(\ell)} \rightleftarrows CH_3COOH_{(aq)} + HO^-_{(aq)}$ | 0,5 | • Write the equation of the acid-base reaction and identify the two pairs involved.<br>• Write and use the expression of the acid dissociation constant $K_A$ associated with the reaction of an acid with water.<br>• Know the relationship $pK_A = -\log K_A$.<br>• Determine the pH value of aqueous solution based on the molar concentration of ions $H_3O^+$ or $HO^-$.<br>• Define the final progress rate of a reaction, and determine it using experimental data.<br>• Determine the equilibrium constant associated to the equation of acid-base reaction using the acid dissociation constants of existing pairs.<br>• Calculate the value of the quotient of reaction $Q_r$ of a chemical system in given state.<br>• Determine the direction of spontaneous evolution of a chemical system. |
| | 2. | Method<br>$[HO^-_{(aq)}] = 7,9.10^{-7}\ mol.L^{-1}$ | 0,25<br>0,25 | |
| | 3. | $\tau = 7,9.10^{-2}\ \%$<br>Limited reaction | 0,25<br>0,25 | |
| | 4. | $Q_{r,éq} = \dfrac{C.\tau^2}{1-\tau}$<br>$Q_{r,éq} = 6,24.10^{-10}$ | 0,25<br>0,25 | |
| | 5. | Check the value of $pK_{A1}$ | 0,5 | |
| | II-1. | $HCOOH_{(aq)} + CH_3COO^-_{(aq)} \rightleftarrows HCOO^-_{(aq)} + CH_3COOH_{(aq)}$ | 0,5 | |
| | 2. | $K = \dfrac{K_{A2}}{K_{A1}}$<br>K=10 | 0,25<br>0,25 | |
| | 3. | $Q_{r,i} = 1$ | 0,5 | |
| | 4. | - the reaction evolves in the direction of producing the ethanoic acid<br>- justification | 0,25<br>0,25 | |
| | 5. | Method<br>pH = 4,27 | 0,25<br>0,25 | |
| Part 2 | 1. | $\ominus Al_{(s)} / Al^{3+}_{(aq)} // Zn^{2+}_{(aq)} / Zn_{(s)} \oplus$ | 0,5 | • Draw a cell diagram / diagram of an electrochemical cell (battery)<br>• Interpret the functioning of a battery based on: the direction of electric current flow, the electromotive force (emf), the electrode reactions, the polarity of electrodes or the movement of charge carriers.<br>• 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).<br>• 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...). |
| | 2. | At the anode :<br>$Al_{(s)} \rightleftarrows Al^{3+}_{(aq)} + 3e^-$<br>At the cathode :<br>$Zn^{2+}_{(aq)} + 2e^- \rightleftarrows Zn_{(s)}$<br>Overall equation :<br>$2Al_{(s)} + 3Zn^{2+}_{(aq)} \rightarrow 3Zn_{(s)} + 2Al^{3+}_{(aq)}$ | 3x0,25 | |
| | 3. | Method<br>$\left[Zn^{2+}_{(aq)}\right]_r = 8,7.10^{-2}\ mol.L^{-1}$ | 0,5<br>0,25 | |

| Exercise 2 (2,75 points) | | | |
|---|---|---|---|
| **Question** | **Answers** | **Marking scale** | **Question reference in the framework** |
| **1.1.** | A | **0,5** | • Define a mechanical wave and its wave speed. |
| **1.2.** | B | **0,5** | • Define a dispersive medium. |
| **2.1.** | explanation | **0,5** | • Exploit the relationship between time delay, distance and wave speed.<br>• Exploit experimental documents and data in order to determine:<br>  • distance;<br>  • time delay. |
| **2.2.** | $d_1 = \frac{v.t_1}{2}$ | **0,5** | |
| **2.3.** | $d_2 = \frac{v.(t_2 - t_1)}{2}$<br>$d_2 = 6,16\,cm$ | **0,5**<br>**0,25** | |

| Exercise 3 (2,5 points) | | | |
|---|---|---|---|
| **Question** | **Answers** | **Marking scale** | **Question reference in the framework** |
| **1.** | 92 protons and 142 neutrons | **0,5** | • Know the meaning (significance) of the symbol $^{A}_{Z}X$ and give the corresponding composition of the nucleus.<br>• Define and calculate the mass defect and the binding energy.<br>• Write the equation of a nuclear reaction by applying the two conservation laws.<br>• Recognize the type of radioactivity using the equation of a nuclear reaction.<br>• Know and exploit the law of the radioactive decay, and exploit its curve. |
| **2.** | Method<br>$E_{\ell} \approx 1731,22\,MeV$ | **0,25**<br>**0,25** | |
| **3.** | $^{234}_{92}U \rightarrow {}^{230}_{90}Th + {}^{4}_{2}He$<br>the type is $\alpha$ | **0,25**<br>**0,25** | |
| **4.1.** | Method<br>$N(^{230}_{90}Th) = N_0(1 - e^{-\lambda t})$ | **0,25**<br>**0,25** | |
| **4.2.** | Method | **0,25** | |
| **4.3.** | $r_1 \approx 0,76$ | **0,25** | |

## Exercise 4 (5,25 points)

| Question | Answers | Marking scale | Question reference in the framework |
|---|---|---|---|
| 1.1. | Method | 0,5 | • Know and exploit the relationship $i = \frac{dq}{dt}$ for a capacitor in receiver convention.<br>• Know and exploit the relationship q = C.u.<br>• Determine the capacitance of a capacitor graphically or by calculation. |
| 1.2. | Check the value of C | 0,5 | |
| 2.1 | Resistance: $R_1=0$ / $R_2=390\Omega$<br>Curve… : $C_1$ / $C_2$<br>State… : underdamped / overdamped | 4x0,125 | • Define and recognize the undamped (periodic), the underdamped (pseudo-periodic) and the overdamped (non-periodic) states.<br>• 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.<br>• Find out the differential equation for the voltage between the capacitor terminals or for its charge $q(t)$ in the damping case. |
| 2.2 | Method | 0,5 | |
| 2.3 | Method | 0,5 | |
| 3.1. | t(ms): 0 / 13 / 20<br>Et(mJ): 0,64 / 0,36 / 0,24 | 3x0,25 | • Exploit experimental documents in order to:<br>• recognize the observed voltages;<br>• recognize the damping states;<br>• highlight the influence of R, L and C on the oscillation phenomenon;<br>• determine the values of the period and the natural period.<br>• Know and exploit the natural period expression.<br>• Explain energetically the three regimes.<br>• Know and exploit the energetic diagrams.<br>• Know and exploit the expression of the total energy in the circuit.<br>• Know and exploit the expression of the magnetic energy stored in a inductor. |
| 3.2. | Dissipation of the energy by Joule effect | 0,5 | |
| 3.3. | Method<br>$i_1 = 4,47.10^{-2}\ A$ | 0,25<br>0,25 | |
| 4.1 | The role is to select the modulated wave | 0,25 | • Know the selective role of the LC (bung circuit) for the modulated voltage.<br>• Recognize the essential components required to assemble an AM radio, and their roles in the demodulation. |
| 4.2 | $C_0 = \frac{1}{4\pi^2 f^2 L}$<br>$C_0 \approx 7,7\ pF$ | 0,5<br>0,25 | |

## Exercise 5 ( 2,5 points)

| Question | Answers | Marking scale | Question reference in the framework |
|---|---|---|---|
| 1.1. | Method | 0,5 | • 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.<br>• Exploit the velocity-time graph: $v_G = f(t)$.<br>• Know and exploit the characteristics of the uniformly accelerated straight line motion and its parametric equations (t is the parameter).<br>• Apply Newton's second law to determine the kinetic quantities $\vec{v}_G$ and $\vec{a}_G$ and dynamic quantities and exploit them. |
| 1.2. | Method | 0,25 | |
| 1.3. | $F = m.a_G$<br>$F = 4\ N$ | 0,25<br>0,25 | |
| 1.4. | Method | 0,25 | |
| 2.1. | Method | 0,5 | |
| 2.2. | Method<br>$V = 3\ m.s^{-1}$ | 0,25<br>0,25 | |

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