الدورة العادية للعام 2010	امتحانات الشهادة الثانوية العامة الفرع : علوم الحياة	وزارة التربية والتعليم العالي المديرية العامة للتربية دائرة الامتحانات
الاسم: الرقم:	مسابقة في مادة الفيزياء المدة ساعتان	

This exam is formed of three exercises in three pages.
The use of non-programmable calculators is recommended.

First Exercise: *(6 points)* *Determination of the resistance of a resistor*

We intend to determine the resistance R of a resistor (R). We thus connect up the circuit represented in figure (1) that is formed of an ideal generator of e.m.f E = 5 V, the resistor (R), an uncharged capacitor (C) of capacitance C = 33 μF and a double switch (K).

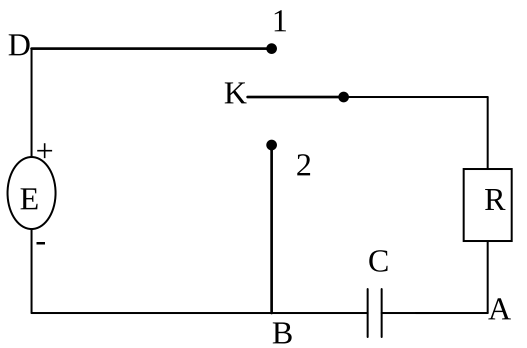


Fig. 1

A – Charging of the capacitor

1) We intend to charge the capacitor. To what position, 1 or 2, must then (K) be moved?

2) The circuit reaches a steady state after a certain time. Give then the value of the voltage u_{AB} across (C) and that of the voltage across (R).

B – Discharging of the capacitor

1) Draw a diagram of the circuit during the discharging of the capacitor and show on it the direction of the current it carries.

2) Derive the differential equation in $u_C = u_{AB}$ during the discharging.

3) The solution of this differential equation has the form :

$u_C = E\, e^{-\frac{t}{\tau}}$ (u_C in V , t in s)

where τ is a constant.

a) Determine the expression of τ in terms of R and C .

b) Determine the value of u_C at the instant $t_1 = \tau$.

c) Give, in terms of τ , the minimum duration needed at the end of which the capacitor is practically totally discharged.

d) Derive the expression of $\ell n\, u_C$, the natural logarithm of u_C , in terms of E , τ and t.

e) The diagram of figure 2 represents the variation of $\ell n\, u_C$ as a function of time .

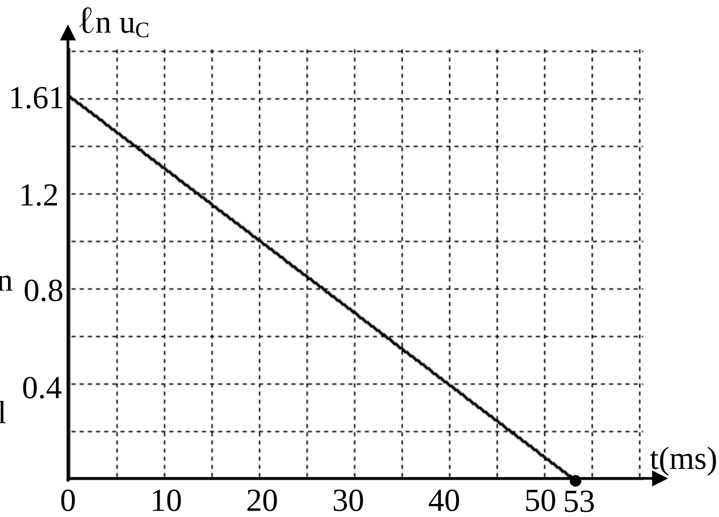
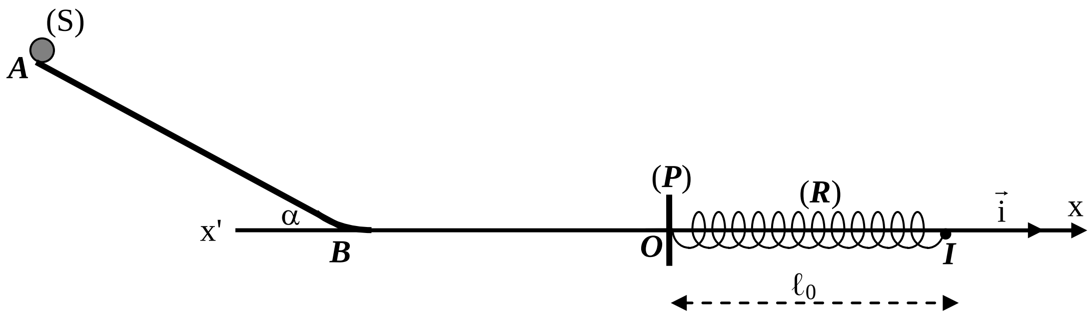


Fig. 2

Referring to the graph of figure 2, determine the value of R.

<u>Second Exercise</u>: (7 points) Horizontal elastic pendulum

A particle (S) of mass $m_1 = 100$ g can slide , without friction, on a track in a vertical plane, formed of a straight part AB , of length 10 cm, inclined by an angle $\alpha = 30^0$ with the horizontal and a straight horizontal part Bx.
A spring (R), of un-jointed turns and of negligible mass, of free length ℓ_0 and of stiffness $k = 10$ N/m, is placed horizontally on the part Bx. One end of the spring is fixed to the track at point I and the other end is fixed to a plate (P). (R) has a free length ℓ_0 and (P) is at point O of the horizontal part (figure below). The point O is taken as the origin of abscissas on the axis x'ox.



The particle (S) is released from rest at point A. The horizontal plane containing Bx is taken as a gravitational potential energy reference. Take $g = 10$ m/s^2.

A – Motion of the particle between A and O

1) Calculate the mechanical energy of the system [(S), Earth] at point A.

2) The mechanical energy of the system [(S), Earth] is conserved between the points A and O. Why?

3) (S) reaches point O with the velocity $\vec{V_0} = V_0\vec{i}$. Show that $V_0 = 1$ m/s.

B – Motion of the oscillator in two situations

I – First situation

The plate (P) has a negligible mass.
(S) collides with (P) and sticks to it thus forming a single body [(P), (S)] whose center of mass is G. At the instant $t_0 = 0$, G is at O. The system [(S), (P), spring] forms a horizontal mechanical oscillator. At an instant t, the abscissa of G is x and the algebraic measure of its velocity is v.

1) Write down the expression of the mechanical energy of the system [oscillator, Earth] in terms of m_1, x, v and k.

2) Derive the second order differential equation in x that governs the motion of G.

3) Deduce the nature of the motion of G and the expression of the period T_1 of this motion in terms of m_1 and k.

4) G , leaving O at the instant $t_0 = 0$, passes again through O for the first time at the instant t_1. Calculate the duration t_1.

II – Second situation

(P) is replaced by another plate (P') of mass $m_2 = 300$ g placed at O. Considering the initial conditions, (S) reaches (P'), just before collision , with the velocity $\vec{V_0} = V_0\vec{i}$ ($V_0 = 1$ m/s). Just after the head-on collision (collinear velocities) , (S) and (P') move separately, at the instant $t_0 = 0$, with the velocities $\vec{V_1}$ and $\vec{V_2} = V_2\vec{i}$ respectively where $V_2 = 0.5$ m/s.

1) Determine $\vec{V_1}$.

2) Show that the collision is elastic.

3) (P') leaves O at the instant $t_0 = 0$ then passes again through point O for the first time at the instant t_2. We notice that the durations t_1 and t_2 are related by $t_2 > t_1$. Justify.

Third Exercise: *(7 points) The radio-isotope polonium* $^{210}_{84}Po$

Given: 1u = 1.66×10^{-27} kg = 931.5 MeV/c^2 ; 1 MeV = 1.6×10^{-13} J ;

Mass of some nuclei : m(Po) = 209.9829 u ; m(Pb) = 205.9745 u ; m(α) = 4.0026 u ;

h = 6.63×10^{-34} J.s ; c = 3×10^{8} m/s.

A – Decay of polonium 210

The polonium $^{210}_{84}Po$ is an α emitter. The daughter nucleus produced by this decay is the lead $^{A}_{Z}Pb$.

1) Determine Z and A specifying the laws used.

2) Calculate, in MeV and in J, the energy liberated by this decay.

3) The nucleus $^{210}_{84}Po$ is initially at rest. We suppose that the daughter nucleus $^{A}_{Z}Pb$ is obtained at rest and in the fundamental state. Deduce the kinetic energy of the emitted α particle.

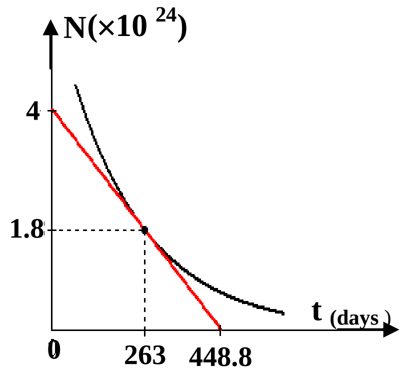
4) In general, the decay of $^{210}_{84}Po$ is accompanied by the emission of γ radiation.

a) Due to what is the emission of γ radiation?

b) The emitted γ radiation has the wavelength $\lambda = 1.35\times10^{-12}$ m in vacuum. Using the conservation of total energy, determine the kinetic energy of the emitted α particle.

B – Radioactive period of polonium 210

The adjacent figure shows the curve representing the variations with time t of the number N of the nuclei present in the radioactive sample $^{210}_{84}Po$, this number being called N_0 at the instant $t_0 = 0$. The same figure shows also the tangent to that curve at the instant t_1 = 263 days.



1) Write down the expression of N as a function of t and specify what does each term represent.

2) The activity of the radioactive sample is given by: $A = -\dfrac{dN}{dt}$.

a) Define the activity A.

b) Using the given on the figure above, determine the activity A of the sample at the instant t_1 = 263 days.

3) Deduce the value of the radioactive constant and the value of the half-life (period) of polonium 210.

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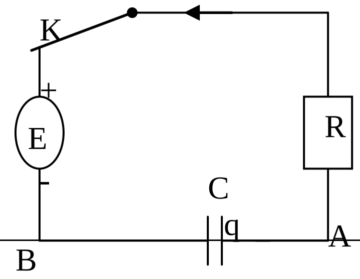
مشروع معيار التصحيح	مسابقة في مادة الفيزياء المدة ساعتان	الاسم: الرقم:

First exercise (6 points)

Part of the Q	Answer	Mark
A.1	We have to move the switch (K) to position 1.	
A.2	After certain time $\Rightarrow$ uc = E = 5 V, $u_R = 0$	
B.1	B.1 	
B.2	q = C u_c, therefore i = - C $\frac{du_C}{dt}$ $u_{AB} = Ri = u_c \Rightarrow - Ri + u_c = 0$ RC $\frac{du_C}{dt} + u_c = 0$.	
B.3.a	$\frac{du_C}{dt} = -\frac{1}{\tau} E e^{\frac{-t}{\tau}} \quad - RC \frac{1}{\tau} E e^{\frac{-t}{\tau}} + E e^{\frac{-t}{\tau}} = 0$ $\Rightarrow \tau = RC$	
B.3.b	$t_1 = \tau \Rightarrow$ uc = 1,85 V.	
B.3.c	$t_{min} = 5\tau$	
B.4.d	$\ell n\, u_c = -\frac{t}{\tau} + \ell n\, E$	
B.3.e	Slope $= -\frac{1}{\tau} = -\frac{1.61}{0.053}$ but $= RC \Rightarrow R = \frac{\tau}{C} = 10^3\ \Omega$.	

Second exercise (7 points)

Part of the Q	Answer	Mark
A.1	$ME_A = KE_A + GPE_A = 0 + m_1gh = m_1g(AB\sin\alpha) = 0.1\times10\times0.1\times0.5$ $ME_A = 0.05$ J	
A.2	friction is negligible	
A.3	$ME_A = ME_O = GPE_O + KE_O = 0 + ½m_1V^2 \Rightarrow V = 1$ m/s.	
B.I.1	$ME = ½\, m_1v^2 + ½\, kx^2$	
B.I.2	$\frac{dME}{dt} = 0 = m_1vx'' + kxv \Rightarrow x'' + \frac{k}{m}x = 0$	
B.I.3	The form is $x'' + \omega_0^2 x = 0$ then Simple harmonic motion $\omega_1 = \sqrt{\frac{k}{m_1}} \Rightarrow T_1 = 2\pi\sqrt{\frac{m_1}{k}}$.	
B.I.4	$t_1 = \frac{T_1}{2} = \pi\sqrt{\frac{m_1}{k}} = \pi\sqrt{\frac{0.1}{10}} = 0.314$ s	
B.II.1	The linear momentum is conserved $m_1\vec{V} + \vec{0} = m_1\vec{V_1} + m_2\vec{V_2} \Rightarrow m_1V = m_1V_1 + m_2V_2$ $\Rightarrow m_1(V-V_1) = m_2V_2 \Rightarrow V_1 = -0,5$ m/s $\Rightarrow \vec{V_1} = -0,5\ \vec{i}$	
B.II.2	$KE_{Before} = ½\, m_1V_0^2 + 0 = 0,05$ J ; $KE_{After} = ½\, m_1V_1^2 + ½\, m_2V_2^2 = 0,05$ J $KE_{Before} = KE_{After} \Rightarrow$ Elastic collision	
B.II.3	The period increases with the mass $\Rightarrow T_2 > T_1 \Rightarrow t_2 > t_1$	

Third exercise (7 points)

Part of the Q	Answer	Mark
A.1	${}^{210}_{84}Po \longrightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$; Using the laws of conservation of charge and mass numbers, Z = 82 and A = 206.	
A.2	$E = \Delta mc^2$, $\Delta m = 209.9829 - (4.0026+205.9745) = 0.0058$ u , … $E = (0.0058)(931.5MeV/c^2)\,c^2 = 5.4$ MeV $= 5.4\times1.6\times10^{-13}$ J $E = 8.64\times10^{-13}$ J	
A.3	$E(\gamma) = 0 \Rightarrow KE_{(\alpha)} = E = 5.4$ MeV $= 8.64\times10^{-13}$ J	
A.4.a	If the obtained daughter nucleus is in an excited state and when drops to the ground state it emits γ rays	
A.4.b	$E(\gamma) = hc/\lambda = 1.4733\times10^{-13}$ J = 0.92 MeV ; $m(Po)c^2 + 0 = m(Pb)\,c^2 + 0 + m(_\alpha)\,c^2 + KE_{(\alpha)} + E(\gamma)$ $\Rightarrow E = \Delta mc^2 = KE_{(\alpha)} + E(\gamma) \Rightarrow KE_\alpha = 5.4 - 0.92 = 4.48$ MeV.	
B.1	$N = N_o\, e^{-\lambda t}$, N_o being respectively the number of nuclei present at $t_0 = 0$ and at t ,λ is the radioactive constant and t is the time .	
B.2.a.i	Activity is the number of decayed nuclei per unit time.	
B.2.a.ii	A = -(slope of the curve) = $\frac{4\times10^{24}}{448.8}$ = 8.91×10^{21} decays /day	
B.2.b	$A = \lambda N$ then $\lambda = A/N = 0.00495$ day^{-1} ; $T = \frac{\ln 2}{\lambda} = \frac{0.69}{0.00495}$ = 140 days	