This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School
for Boys and Girls Loueizeh - Baabda

Stage Exam 04
20-25JUN2025

Do NOT write in this box. Your MARK will be placed here.

Subject :	Physics
Class :	12E
Teacher :	Mr. Ali Moukalled
Duration :	2 hours
You are to answer the questions to this exam on : Squared paper	

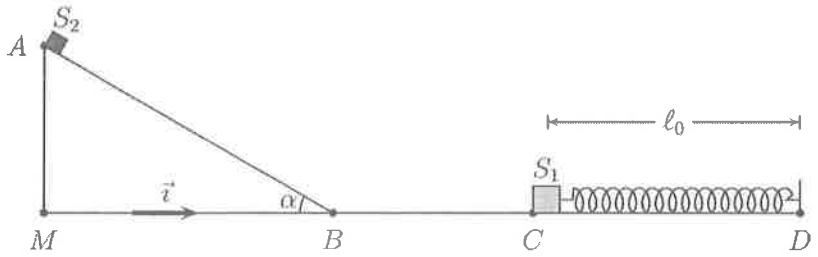
Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

EXERCISE 1 (10 points)

Mechanical energy of a system

A small solid (S), of mass $m_1 = 100g$, is left without initial velocity from a point A of the path shown in the figure below.



(S_1) slides from A to B then it continues its motion on BC to meet at the point C the solid (S_2) whose mass is $m_2 = 200g$ that is initially at rest and which is attached to an un-stretched spring of natural length ℓ_0 and of stiffness constant $K = 80N/m$ and of negligible mass. The path AB has a length of $40m$ and it is inclined by $\alpha = 30°$ with the horizontal, AB is perfectly smooth whereas the path $BC = 25m$ is rough and exerts a constant force of friction f. The level of the horizontal plane passing through BC is taken as a reference for the gravitational potential energy.

1. Motion of (S) on AB

(a) Calculate, at A, the mechanical energy of the system $((S)$, earth).

(b) Is the mechanical energy of the system $((S)$, earth) conserved? Why?

(c) Calculate the velocity of (S) at the passage through the point B.

2. Motion of (S) on BC

The solid (S_1) hits the solid (S_2) at the velocity $V_1 = 15m/s$.

(a) Calculate, at C, the mechanical energy of the system $(S_1$, earth).

(b) The mechanical energy of the system $(S_1$, earth) is not conserved. Why?

(c) Calculate f.

3. Collision between S_1 and S_2.

The solid (S_1) enters in a head-on elastic collision with (S_2) which can move solely on the axis BD on which we have a unit vector $\vec{i}$.

(a) Determine the velocities $\vec{V}'_1$ and $\vec{V}'_2$ of S_1 and S_2 respectively right after the collision.

(b) Knowing that the duration of the collision is $0.05s$, determine value of the average force $\vec{F}_{21}$ exerted by S_2 on S_1 during the collision. Deduce with justification the value of the average force $\vec{F}_{12}$ exerted by S_1 on S_2.

(c) Determine the maximum compression X_m of the spring knowing that the force of friction, on CD, is supposed negligible.

(d) Specify, on CB, the point where m_1 stops.

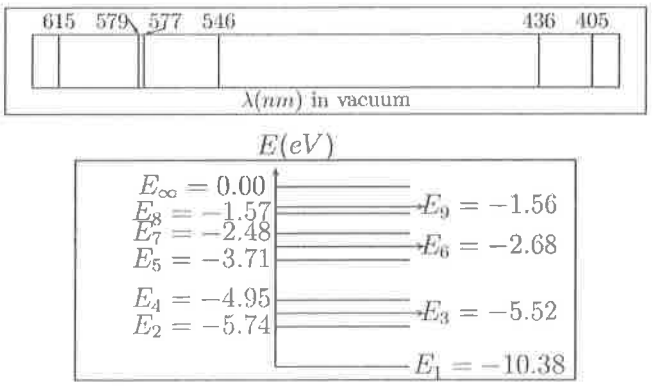
EXERCISE 2 **(10 points)**

Mercury atom :

Planck's constant : $h = 6.626 \times 10^{-34} J \cdot s$, $c = 2.998 \times 10^{8} m/s$, $e = 1.602 \times 10^{-19} C$.

A. Transitions:

The figure below shows a part of the emission spectrum of a lamp of mercury vapor (M) and the energy diagram of some energy levels of the mercury atom.



1. The energy levels of the mercury atom are quantized. Justify.
2. Calculate the ionization energy of the atom when it is in each of the energy levels ; "E_1" and "E_5".
3. A mercury atom found in the energy state "E_9", returns toward the ground state passing successively by the levels "E_5" and "E_2".
   (a) Determine the transition to which a radiation of wavelength $577nm$ is associated.
   (b) Justify then the presence of a yellow doublet $577.579nm$.
4. Explain what happens when :
   (a) An electron of energy $6eV$ enters in collision with an atom of mercury taken in the ground state.
   (b) A photon of energy $6eV$ enters in collision with an atom of mercury taken in the ground state.

B. Planck's constant:

The yellow doublet is considered as one line spectrum of wavelength $578nm$. The lamp (M), equipped with many filters, illuminates the cathode of cesium of a photoelectric cell whose work function $W_0 = 2.15eV$. For each of the wavelengths, we measure the maximum kinetic E_k of the emitted electrons (See table below).

$\lambda(nm)$	615	578	546	436	405
E_k	0	0	0.18	0.75	0.97

1. Determine the expression of E_k as a function of $\frac{1}{\lambda}$.
2. Determine the value of planck's constant.
3. (a) Determine the threshold wavelength λ_0 associated to cesium.
   (b) Interpret the presence of zeros in the table.
4. (a) The photoelectric effect puts in evidence one of the aspects of light. Which one?

EXERCISE 3 **(10 points)**

Study of a sample of Radon 219

A- Study of the stability of a Radon 219 nucleus .

The mass of a Radon nucleus $^{219}_{86}Rn$ is $219.009481u$, the mass of a proton is 1.007285, the mass of a neutron is $1.008665u$; $1u = 931.5Mev/c^2$.

1. Calculate the binding energy per nucleon of a Radon nucleus.
2. The binding energy of a polonium 215 nucleus is $1627Mev$. Compare the stability of Polonium 215 to that of Radon 219.

B- Period of Radon 219.

We measure at different instants, separated by a constant duration of 8 seconds, the activity of a Radon 219 sample, the results are tabulated in the table below. Given: $1Ci = 3.7 \times 10^{10}Bq$.

t: time(s)	0	8	16	24	32
A: Activity(Ci)	10000	2500	625	156.25	39.0625
$\ell n(A)$	9.2	7.8	6.4	5	3.7

1. Define the activity (A) and the period (T) of a radioactive sample.
2. Plot the graph representing the variation of $\ell n(A)$ as a function of time.
3. Deduce graphically the value of the period of Radon 219 and calculate the value of the radioactive constant λ.
4. Deduce the number of nuclei N_0 of Radon 219 found in the sample at the instant $t = 0$.

C- Disintegration of Radon 219

The Radon nucleus $^{219}_{86}Rn$ is an α emitter it is transformed into Polonium Po. By measuring the maximum distance traveled by the α particle in a room full of bubbles, we are able to determine its kinetic energy.

1. Write, indicating the laws used, the equation of the disintegration of Radon 219.

2. The daughter nucleus might be in the ground state or in the excited state.
   (a) What is the nature of radiations emitted by the daughter nucleus during its de-excitation.
   (b) Under Which form(s) appear the energy liberated by the disintegration of a Radon 219 nucleus if the nucleus is born:
      i. in the ground state.
      ii. in the excited state.
   (c) During the disintegration of the sample of Radon 219, the kinetic energy of the emitted α particles are: $6.82Mev$; $6.55Mev$; or $6.43Mev$. Neglecting the kinetic energy of the daughter nucleus.
      i. One of the emitted α particles is not accompanied by the emission of a γ particle. Which one ? Justify.
      ii. Deduce, in each case, the energies of the emitted γ radiations.
      iii. Calculate the power of the sample at the instant $t = 8s$. Given: $1Mev = 1.6 \times 10^{-13}J$.

SE04/2024 2025/Physics/12E/ SOLUTION

Exercise 1

$m_1 = 100g = 0.1Kg$ $V_A = 0m/s$ $m_2 = 0.2Kg$ $K = 80 N/m$.
$\alpha = 30°$ $BC = 25m$

1. Motion of (S) on AB

a) $M.E_A = K.E_A + G.P.E_A$
$= 0 + m_1 g h_A$
$= m_1 g AB \sin\alpha$
$= 0.1 \times 10 \times 40 \times \sin 30$
$= 20J$ (0.5)

$M.E_A = 20J$

b) Yes, due to the absence of friction. (0.25)

c) $M.E_A = M.E_B$
$20 = K.E_B + G.P.E_B$

$20 = \frac{1}{2} m_1 V_B^2$

$\frac{2 \times 20}{m_1} = V_B^2$ (0.5)

$V_B^2 = 400$

$V_B = 20m/s$

2. Motion of (S) on BC

$V_1 = 15\ m/s$

a) $M.E_C = K.E_C + G.P.E_C$

$= \frac{1}{2} m_1 V_1^2$

$= \frac{1}{2}(0.1)(15)^2$

$= 11.25\ J$ (0.5)

$M.E_C = 11.25\ J$

b) Due to the existance of friction (0.25)

c) $\Delta M.E = -f \times BC$

$M.E_C - M.E_B = -f \times BC$ (0.5)

$11.25 - 20 = -f \times 25$

$f = 0.35\ N$

3. Collision between S_1 and S_2

a) During collision, the linear momentum is conserved

$$\overrightarrow{P}_{\substack{\text{just}\\\text{before}\\\text{collision}}} = \overrightarrow{P}_{\substack{\text{just}\\\text{after}\\\text{collision}}}$$

$\vec{P_1} + \vec{P_2} = \vec{P_1}' + \vec{P_2}'$

$m_1\vec{V_1} = m_1\vec{V_1}' + m_2\vec{V_2}'$

$m_1V_1 = m_1V_1' + m_2V_2'$ (1)

$m_1V_1 - m_1V_1' = m_2V_2'$ (1)

$m_1(V_1 - V_1') = m_2V_2'$ (2)

The collision is Elastic,

K.E before collision = K.E after collision.

$K.E_1 + K.E_2 = K.E_1' + K.E_2'$

$\frac{1}{2}m_1V_1^2 = \frac{1}{2}m_1V_1'^2 + \frac{1}{2}m_2V_2'^2$

$m_1V_1^2 - m_1V_1'^2 = m_2V_2'^2$ (1)

$m_1(V_1^2 - V_1'^2) = m_2V_2'^2$

$m_1(V_1 - V_1')(V_1 + V_1') = m_2V_2'^2$ (3)

(3)/(2)

$\frac{m_1(V_1 - V_1')(V_1 + V_1')}{m_1(V_1 - V_1')} = \frac{m_2V_2'^2}{m_2V_2'}$

$V_1 + V_1' = V_2'$ $\quad V_1' - V_2' = -V_1$ (4)

$$\begin{cases} m_1 V_1 = m_1 V_1' + m_2 V_2' \\ (-V_1 = V_1' - V_2') \times m_2 \end{cases}$$

$$\begin{cases} m_1 V_1 = m_1 V_1' + m_2 V_2' \\ -m_2 V_1 = m_2 V_1' - m_2 V_2' \end{cases}$$

$$V_1' (m_1 + m_2) = m_1 V_1 - m_2 V_1$$

$$V_1' = \frac{m_1 V_1 - m_2 V_1}{m_1 + m_2} = \frac{0.1 \times 15 - 0.2 \times 15}{0.1 + 0.2}$$

$$V_1' = -5 \text{ m/s} \quad (1)$$

Replace V_1' in (4)

$$V_1' - V_2' = -V_1$$
$$V_1' + V_1 = V_2'$$

$$-5 + 15 = V_2'$$

$$V_2' = 10 \text{ m/s} \quad (1)$$

b) $\Delta t = 0.05\ s$

$F_{2/1} = ?$

Due to Newton's 2nd law

$$\Sigma \vec{F}_{ext} = \frac{\Delta \vec{P}}{\Delta t}$$

$$m_1\vec{g} + \vec{N}_1 + \vec{F}_{2/1} = \frac{\vec{P}_1' - \vec{P}_1}{\Delta t}$$

project along the x-axis (0.5)

$$-F_{2/1} = \frac{m_1 V_1' - m_1 V_1}{\Delta t}$$

$$-F_{2/1} = \frac{0.1 \times (-5) - 0.1(15)}{0.05}$$

$$-F_{2/1} = -40 \quad (0.5)$$

$$F_{2/1} = 40N$$

$F_{1/2} = F_{2/1} = 40N$ due to Newton's third law, for every action there is an equal but opposite reaction. (0.5)

c) In the absence of friction the M.E is conserved

$$M.E_c = M.E_{x_m}$$

$$K.E_c = E.P.E$$

$$\frac{1}{2} m_2 V_2'^2 = \frac{1}{2} K x_m^2$$

$$x_m^2 = \frac{m_2 V_2'^2}{K} = \frac{0.2 \times 10^2}{80} = 0.25$$ (1)

$$x_m = 0.5\,m$$

d) $\Delta M.E = -F_r \times BE$ (E between B & C)

$$M.E_E - M.E_C = -f_r \times BE$$

$$-\frac{1}{2} m_1 V_1'^2 = -f_r \times BE$$

$$-0.5\,(0.1)(5)^2 = -0.35 \times BE$$ (1)

$$BE = 3.57\,m$$

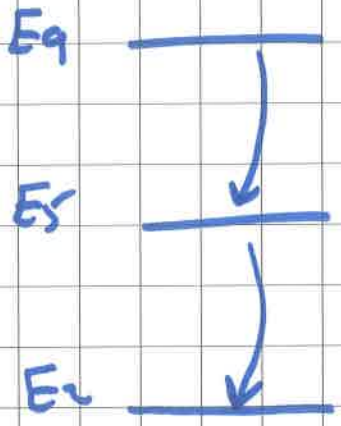
Ex2

1) They take specific energy levels (0.5)

2) $E_0 - E_1 = 0 + 10.38 = 10.38\ eV$

$E_4 - E_5 = 0 + 3.71 = 3.71\ eV$ (0.5)

3) Eq.



(1)

a) $E_q - E_s = -1.56 + 3.71$

$= 2.15\ eV$

$= 3.44 \times 10^{-19}\ J$

$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{3.44 \times 10^{-19}}$ (1)

$E = 5.77 \times 10^{-7}\ m$

$= 577\ nm$

b) Nm two lines belong to the same color (1)

(4)

4) a) $-4.95 + 10.38 = 5.43$ eV

So it ⇒ get excited to E_3. (1)

b) It remains in the ground state. (0.5)

B- 1) $E_{photon} = W_o + E_K$

$E_K = E_{photon} - W_o$ (1)

$E_K = \frac{hc}{\lambda} - W_o$

$E_K = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{\lambda} - W_o$

2) $E_K = \frac{1.242 \times 10^{-6}}{\lambda} - 2.15$ (1)

2) $h = 6.262 \times 10^{-34}$ J.s (0.5)

3) a) $\lambda_o = 615 \times 10^{-9}$ m (0.5)

3) b) For Both zeros, the electron is extracted without K.E (1)

4) a) Corpuscular aspect of light (0.5)

Exercise 3

A- Study of the stability of a Radon 219 nucleus

$m_{Rn} = 219.009481\ u$ $\quad m_p = 1.007285\ u$ $\quad m_n = 1.008665\ u$

1) $\Delta m_{Rn} = [Z m_p + N m_n] - m_{Rn}$

$= [(86 \times 1.007285) + (133 \times 1.008665)] - 219.009481$

$\Delta m = 1.893615\ u$ (0.5)

$E_B = \Delta m c^2$

$= 1.893615\ u \times c^2$

$= 1.893615 \times 931.5\ MeV/c^2 \times c^2$

$= 1763.902373\ MeV$ (0.5)

$\left(\frac{E_B}{A}\right)_{Rn} = \frac{1763.902373}{219} = 8.05\ MeV/nucleon$

2) $\left(\frac{E_B}{A}\right)_{Po} = \frac{1087}{215} = 7.567\ MeV/nucleon$ (0.5)

$\left(\frac{E_B}{A}\right)_{Rn} > \left(\frac{E_B}{A}\right)_{Po}$

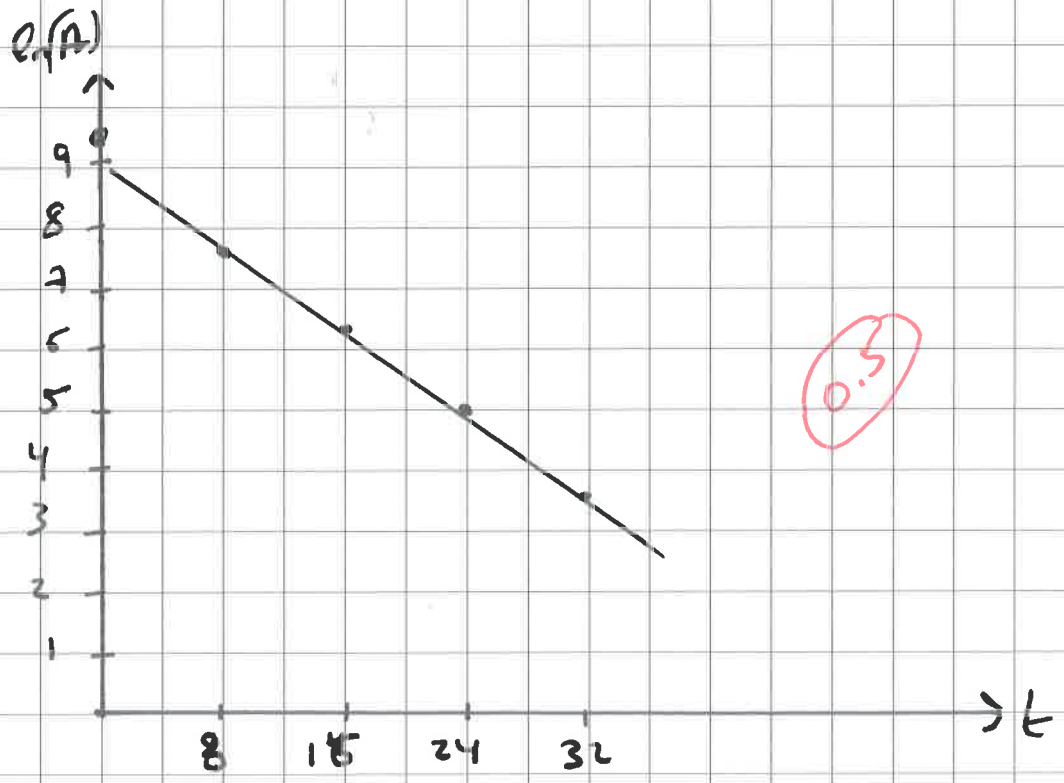
So Rn is more stable

B- Period of Radon 219

1) Activity: number of decays per second
Period: the time needed for a radioactive sample to get half decayed (0.5)

2)

t	0	8	16	24	32
A (Ci)	10000	2500	625	156.25	39.062
ln A	9.2	7.8	6.4	5	3.7



(0.5)

3) λ = slope

$$\lambda = \frac{\ln A_2 - \ln A_1}{t_2 - t_1}$$

$$= \left| \frac{7.8 - 9.2}{8 - 0} \right| \quad (1)$$

$$\lambda = 0.175\ s^{-1}$$

$$T = \frac{\ln 2}{\lambda} = \frac{\ln 2}{0.175}$$

$$T = 3.96\ s \quad (0.5)$$

4) $A_0 = 10000\ Ci$

$$= 10000 \times 3.7 \times 10^{10}$$

$$= 3.7 \times 10^{14} \quad (1)$$

$$A_0 = \lambda N_0$$

$$N_0 = \frac{A_0}{\lambda} = \frac{3.7 \times 10^{14}}{0.175} \quad (1)$$

$$N_0 = 2.11428 \times 10^{15}\ \text{Nuclei}$$

C- Disintegration of Radon

1) $^{219}_{86}Rn \longrightarrow {}^{A}_{Z}Po + {}^{4}_{2}He$

A = 215
Z = 84
} due to Soddy's law (1)

2) a) electromagnetic radiation (0.5)

b) i) $K.E_{He} + K.E_{Po}$ (0.7)

ii) $K.E_{He} + K.E_{Po} + E\gamma$ (0.3)

c) $K.E_{\alpha_1} = 6.82\ MeV$

$K.E_{2\alpha_2} = 6.55\ MeV$ (0.5)

$K.E_{\alpha_3} = 6.47\ MeV$

i) $K.E_{\alpha_1} = 6.82\ MeV > K.E_{\alpha_2} > K.E_{\alpha_3}$ (0.5)

ii) You need to calculate $E_{1,b}$

then $E\gamma_2 = E_{1,b} - K.E_{\alpha_2}$ (0.3)

$E\gamma_3 = E_{1,b} - K.E_{\alpha_3}$