المركز التربوي للبحوث والإنماء	الهيئة الأكاديميّة المشتركة قسم: العلوم	المادة: الفيزياء الشهادة: الثانوية العامّة فرعا: الإجتماع والاقتصاد / الآداب والإنسانيات نموذج رقم 2 المدّة: ساعة واحدة

نموذج مسابقة (يراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

This test includes three mandatory exercises. The use of non-programmable calculators is allowed.

Exercise 1 (7 points) Scintigraphy

A hepatic scintigraphy is an imaging test used to examine the liver. A radioactive nuclide, gold $^{198}_{79}\text{Au}$, is injected into a patient's veins thus allowing to obtain images of the liver by using a special radiographic device.

A gold nucleus $^{198}_{79}\text{Au}$ is a β^- emitter. The average kinetic energy of the electron emitted during a decay is 0.96 MeV and the energy of the γ radiation emitted is 0.412 MeV.

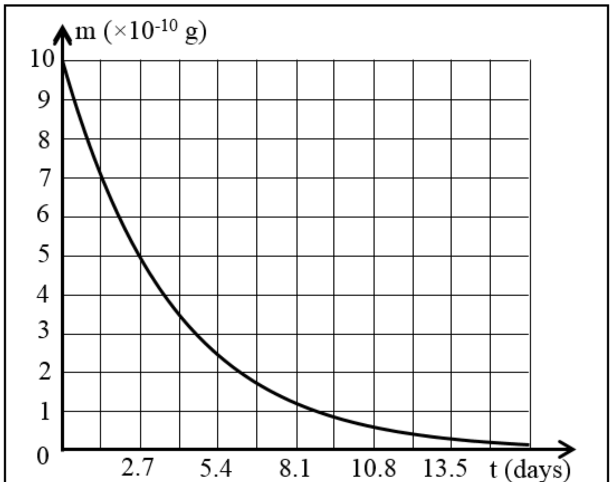
In this exercise, we will study the health complications that may develop in a patient when an amount of 10^{-9} g of gold nuclei $^{198}_{79}\text{Au}$ is introduced into the liver of mass m = 800 g.

Given:

$1\text{u} = 1.66\times10^{-27}$ kg; $1 \text{ MeV} = 1.6\times10^{-13}$ J;

Mass of a $^{198}_{79}\text{Au}$ nucleus = 197.968 u;

The Relative Biological Efficiency of β^- and that of γ is RBE = 1.



(Doc 1) The mass of gold (198) as a function of time

1) The disintegration of a $^{198}_{79}\text{Au}$ nucleus takes place according to the following equation: $^{198}_{79}\text{Au} \rightarrow {}^{A}_{Z}\text{Hg} + {}^{0}_{-1}\text{e} + \gamma$

- **1-1)** Determine the values of A and Z while indicating the used laws.
- **1-2)** Define the half-life of a radioactive substance.
- **1-3)** Using the document (Doc 1), determine:
  - **1-3-1)** The half-life, T, of $^{198}_{79}\text{Au}$;
  - **1-3-2)** The mass of $^{198}_{79}\text{Au}$ nuclei remaining after 5.4 days.

2) Assume that the gold of mass 10^{-9} g is completely disintegrated before being eliminated from the body.

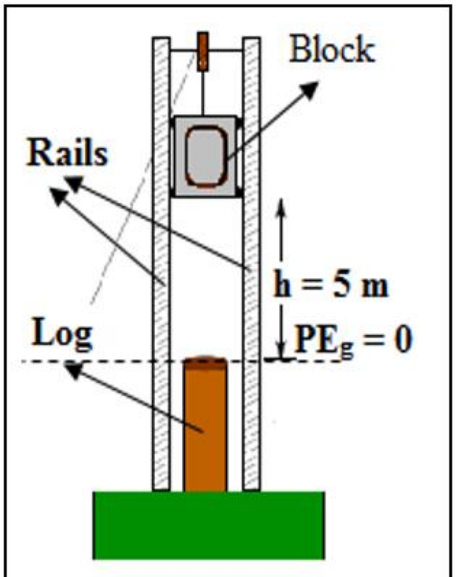
- **2-1)** Show that the number of nuclei contained in 10^{-9} g of gold is 3.04×10^{12}.
- **2-2)** Calculate the energy liberated by the total disintegration of this amount of gold, due to:
  - **2-2-1)** The β^- radiation;
  - **2-2-2)** The γ rays.
- **2-3)** Suppose that the examined liver absorbs 50% of the energy liberated due to the β^- radiation and 10% of the energy liberated due to the γ rays.
  - **2-3-1)** Calculate, in joule, the energy due to the β^- radiation and that due to the γ rays that the liver may absorb.
  - **2-3-2)** Deduce the dose that may be absorbed by the liver due to the β^- radiation and that due to the γ rays.
  - **2-3-3)** Determine the total physiological equivalent dose received by the liver, knowing that it is equal to the sum of the two physiological equivalent doses due to β^- radiation and to γ rays.
  - **2-3-4)** Using table of (Doc 2), describe the consequences that may develop due to the injected quantity of gold.

Physiological equivalent of Dose in Sv	Consequences
>10	100% mortality
5	50% mortality; cancers; blood disorders…
2	10% mortality; cancers, diarrhea; vomiting…
1	Digestive disorders; sterility; increased risk of cancer
0.05	Modification of blood formula…

(Doc 2)

Exercise 2 (6 ½ points) Mechanical Energy

A pile driver is a device that can be used to drive a large object, such as a log, into the ground, by releasing a large metal block.
In this exercise, the block of mass 100 kg, is lifted vertically upward and released from rest at a height h = 5 m above the upper part of the log, which is considered as the reference level of the gravitational potential energy, as shown in the adjacent document (Doc 3).
Take: $g = 10\ m/s^2$.



(Doc 3)

1) The forces of friction is assumed to be negligible.
 1-1) At the instant when the block is released from rest:
  1-1-1) Calculate its kinetic energy;
  1-1-2) Calculate the gravitational potential energy of the system (block, Earth);
  1-1-3) Deduce the mechanical energy of the system (block, Earth).
 1-2) The mechanical energy of the system is conserved. Justify.
 1-3) Deduce the kinetic energy of the block just before it hits the log.
 1-4) Determine the speed v of the block just before it hits the log.

2) In reality, the speed of the block, just before it hits the log, is v' = 9 m/s.
 2-1) Calculate, at this instant, the mechanical energy of the system (block, Earth).
 2-2) Indicate the form in which the lost mechanical energy appears.

Exercise 3 (6 ½ points) Eris and Pluto

In 2005, Mike Brown and his team detected a massive object in the solar system, orbiting the Sun.
It was later named Eris. So far, it has only one known satellite, called Dysnomia.
Below is the identity card of Eris:

Mass: $M_E = 1.67\times10^{22}$ kg	Diameter = 2326 km
Period of rotation = 26 hours	Period of revolution = T_E = 558 Earth years

1) A day on Eris and a day on Earth have approximately the same duration. Justify.

2) The motion of Dysnomia around Eris can be described using Kepler's laws of planetary motion.
 2-1) State Kepler's laws.
 2-2) Describe the trajectory of the center of Dysnomia around Eris.
 2-3) Indicate how the speed of Dysnomia changes during its motion around Eris.
 2-4) The period of revolution of Pluto is T_P = 248 Earth years. Which of the celestial bodies, Eris or Pluto, is closer to the Sun. Justify.

3) Dysnomia moves in its orbit around Eris due to a force exerted by Eris on it.
 3-1) Name this force.
 3-2) Indicate how the magnitude of this force changes with respect to the distance between their centers.

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أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

Exercise 1 (7 points) Scintigraphy

Question	Answer	Mark
1-1	By applying Soddy's laws: Conservation of the mass number: $198 = A + 0 \Rightarrow A = 198$ Conservation of the charge number: $79 = Z - 1 \Rightarrow Z = 80$	¼ ¼ ¼
1-2	The half-life of a radioactive substance is the time it takes for half of the radioactive substance to decay.	½
1-3-1	Referring to the document (Doc 1), the initial mass $m_0 = 10 \times 10^{-10}$ g. When the mass becomes $m_0/2 = 5 \times 10^{-10}$ g, the duration is: T = 2.7 days.	½
1-3-2	After 5.4 days, the remaining mass is 2.5×10^{-10} g.	¼
2-1	The mass of the nucleus is: 197.968 u $= 197.968 \times 1.66\times10^{-27}$ kg $= 3.286\times10^{-25}$ kg $= 3.286\times10^{-22}$ g. The number of nuclei in 10^{-9} g is: $10^{-9}/3.286\times10^{-22} = 3.04\times10^{12}$ nuclei.	½ ½
2-2-1	The Energy of β^- liberated by the total disintegration of 10^{-9}g: $3.04\times10^{12} \times 0.96$ MeV $= 2.92\times10^{12}$ MeV	½
2-2-2	The Energy of γ liberated by the total disintegration of 10^{-9}g: $3.04\times10^{12} \times 0.412$ MeV $= 1.25\times10^{12}$ MeV	½
2-3-1	Energy of β^- absorbed by the liver: $E_{absorbed}(\beta^-) = (50/100) \times 2.92\times10^{12}$ MeV $= 1.46\times10^{12}$ MeV $\Rightarrow$ $E_{absorbed}(\beta^-) = 1.46\times10^{12} \times 1.6\times10^{-13}$ J $= 0.2336$ J Energy of γ absorbed by the liver: $E_{absorbed}(\gamma) = (10/100) \times 1.25\times10^{12} = 0.125\times10^{12}$ MeV $\Rightarrow$ $E_{absorbed}(\gamma) = 0.125\times10^{12} \times 1.6\times10^{-13}$ J $= 0.02$ J	½ ½
2-3-2	Absorbed dose by the liver due to the β^- radiation: $D(\beta^-) = E_{absorbed}(\beta^-)/m = 0.2336/0.8 = 0.292$ Gy (or 0.292 J/kg). Absorbed dose by the liver due to the γ rays: $D(\gamma) = E_{absorbed}(\gamma)/m = 0.02/0.8 = 0.025$ Gy (or 0.025 J/kg).	½ ½
2-3-3	Physiological equivalent $= D(\beta^-) \times EBR(\beta^-) + D(\gamma) \times EBR(\gamma)$ Physiological equivalent $= 0.292 \times 1 + 0.025 \times 1 = 0.317$ Sv.	½ ¼
2-3-4	According to the table, the consequences can be: Digestive disorders, sterility, risks of cancer…	¼

Exercise 2 (6 ½ points) Mechanical Energy

Question	Answer	Mark
1-1-1	$KE_0 = ½ mv_0^2 = 0$ J because $v_0 = 0$ m/s	½
1-1-2	$PE_{g0} = mgh_0$ $PE_{g0} = 0 + 5000 = 5000$ J	½ ½
1-1-3	$ME_0 = PE_{g0} + KE_0$ $ME_0 = 0 + 5000 = 5000$ J	½ ½
1-2	Since the friction is negligible, then the mechanical energy is conserved.	½
1-3	$ME = ME_0 = 5000$ J $ME = PE_g + KE$ $KE = ME – PE_g$ $KE = 5000 – 0$ $KE = 5000$ J	½ ½
1-4	$KE = ½ mv^2$ $v = \sqrt{\frac{2KE}{m}}$ $v = \sqrt{\frac{2 \times 5000}{100}}$ $v = 10$ m/s	 ½ ½
2-1	$KE' = ½ mv'^2$ $KE' = ½ (100)\times(9)^2 = 4050$ J $PE_g' = 0$ J $ME' = PE_g' + KE' = 0 + 4050 = 4050$ J	 ½ ½
2-2	The lost mechanical energy is transformed into heat.	½

Exercise 3 (6 ½ points) Eris and Pluto

Question	Answer	Mark
1	The period of rotation of Eris is 26 hours. The period of rotation of Earth is 24 hours. The two periods are approximately equal.	 ½
2-1	1st law: The planets move along ellipses around the Sun that is at one of the foci. 2nd law: The velocity of the planet decreases as the distance from the Sun increases and vice versa. 3rd law: The period of revolution of the planet increases along with the average distance from the Sun.	½ ½ ½
2-2	It is an ellipse with Eris occupying one of the two foci.	1
2-3	When Dysnomia gets closer to Eris, its speed increases and when it moves further from Eris, its speed decreases.	1
2-4	$T_P < T_E$ therefore Pluto is nearer to the Sun than Eris.	1
3-1	Gravitational force.	½
3-2	The magnitude of the gravitational force is inversely proportional to the square of the distance separating the planet and its satellite.	1