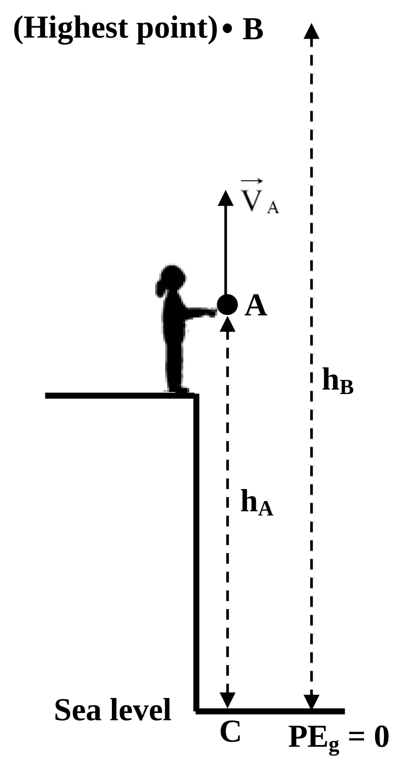
مسابقة في الثقافة العلمية- مادة الفيزياء — الاسم:
المدة ساعة واحدة — الرقم:

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

Exercise 1: (7 ½ points)

Mechanical energy

A girl standing on a platform throws a stone, considered as a particle of mass m = 0.1 kg, vertically upwards from point A found at a height h_A = 30 m above sea level. The stone is launched from point A with a speed V_A = 12 m/s, reaches its maximum height at point B, and then it falls down to reach point C at sea level (Doc. 1).



Doc. 1

Take:

- the sea level as a gravitational potential energy reference for the system [stone, Earth];
- g = 10 m/s^2.

1- Calculate, at point A, at the launching instant:

1-1) the kinetic energy of the stone;
1-2) the gravitational potential energy of the system [stone, Earth];
1-3) the mechanical energy of the system [stone, Earth].

2- In this part, air resistance is neglected.

2-1) Specify the value of the mechanical energy of the system [stone, Earth] at point B.
2-2) Determine the maximum height h_B reached by the stone above sea level.
2-3) Determine the speed V_C of the stone as it reaches point C.

3- In reality air resistance is not neglected. The stone reaches point C with a speed V'_C = 21 m/s.

3-1) Calculate the new value of the mechanical energy of the system [stone, Earth] at point C.
3-2) Calculate the decrease in the mechanical energy of the system [stone, Earth] between points A and C.
3-3) In what form of energy does this decrease in mechanical energy appear?

<u>Exercise 2</u>: (6 ½ points)

The americium-241 nucleus

The americium nucleus $^{241}_{95}Am$ is a radioactive nucleus which is usually used in archeology.

1- Indicate the number of protons and that of nucleons in the nucleus of americium $^{241}_{95}Am$.

2- The reaction of disintegration of americium $^{241}_{95}Am$ is given by :

$$^{241}_{95}Am \rightarrow \ ^{237}_{93}Np + \ ^{A}_{Z}X + \gamma$$

2-1) Define radioactivity.

2-2) Calculate A and Z indicating the used laws.

2-3) Indicate the name and the symbol of the emitted particle $^{A}_{Z}X$.

2-4) This disintegration is accompanied with the emission of γ radiation. Indicate:

2-4-1) the cause of the emission of the γ radiation;

2-4-2) the nature of the γ radiation.

3- The energy liberated due to this disintegration of the americium-241 nucleus is E = 5.63 MeV. Calculate, in kg, the mass defect Δm due to this disintegration.

Given:
1 MeV = 1.6×10^{-13} J ; speed of light in vacuum c = 3×10^{8} m/s.

<u>Exercise 3</u>: (6 points)

Mars

Mars, the red planet, is the fourth planet according to its average distance from the Sun.
It is a terrestrial planet which can be observed by the naked eye.
The period of revolution of Mars is T_M = 1.881 years, whereas that of Earth is T_E = 1 year = 365.25 days.

Doc. 2

1- Name the terrestrial planets of our solar system.

2- Pick out from document 2 an indicator which shows that Mars:

2-1) is a rocky planet;

2-2) contains large quantities of iron oxide in the rocks and stones scattered on its surface.

3- Document 2 indicates the periods of revolution of Mars and Earth.

3-1) What does the « period of revolution » of a planet represent?

3-2) Calculate, in days, the period of revolution of Mars.

3-3) Using the periods of revolution of Mars and Earth, specify which of the two planets is closer to the Sun.

3-4) State Kepler's law which confirms the answer of question (3-3).

مسابقة في الثقافة العلمية- مادة الفيزياء
أسس التصحيح

Exercise 1: (7 points) Mechanical energy

Part		Answer	Grade
1	1-1	$KE_{(A)} = \frac{1}{2} m V_A^2 = \frac{1}{2} \times 0.1 \times (12)^2 = 7.2$ J	1
	1-2	$PE_{g(A)} = mgh_A = 0.1\times10\times30 = 30$ J	1
	1-3	$ME_{(A)} = KE_{(A)} + PE_{g(A)} = 7.2 + 30 = 37.2$ J	1
2	2-1	$ME_B = ME_A$ because air resistance is neglected Then, $ME_B = 37.2$ J	0.25 0.25 0.5
	2-2	$ME_B = KE_B + P.E_{g(B)}$ But $KE_B = 0$ (Stone is at maximum height) Then, $ME_B = PE_{g(B)} = mg\,h_B$ $37.2 = 0.1\times10\times h_B$; $h_B = 37.2$ m	0.25 0.25 0.5
	2-3	$ME_C = KE_C + PE_{(g)C}$ But $PE_{(g)C} = 0$ (Stone is at reference level) Then, $ME_C = KE_C = 37.2$ J $37.2 = \frac{1}{2} \times 0.1 \times V_C^2$; $V_C = 27.27$ m/s	0.25 0.25 0.5
3	3-1	$ME_{new} = KE_{new} + PE_{(g)\ sea\ level}$ But $PE_{(g)\ sea\ level} = 0$ (On the reference level) $ME_{new} = \frac{1}{2} \times 0.1 \times (21)^2 = 22.05$ J	0.5
	3-2	The mechanical energy decreases by: $ME_A - ME_C = 37.2 - 22.05 = 15.15$ J	0.5
	3-3	The form is thermal energy	0.5

Exercise 2 (6½ points) The americium-241 nucleus

Question			Answers	Mark
1			The number of protons is Z = 95 The number of nucleons is A = 241	**0.5** **0.5**
2	2-1		Radioactivity is a spontaneous transformation of a nucleus into another, with emission of radioactive radiation.	**1**
	2-2		Laws of conservation of mass number and charge number (Soddy's laws) 241 = 237 + A, then A = 4 95 = 93 + Z, then Z = 2	**0.25** **0.5** **0.5**
	2-3		Helium nucleus Symbol : ${}^{A}_{Z}X = {}^{4}_{2}He$	**0.25** **0.5**
	2-4	2-4-1	Gamma radiation is emitted due to the downward transition (de-excitation) of the daughter nucleus ${}^{237}_{93}Np$	**0.5**
		2-4-2	Electromagnetic radiation	**0.5**
3			$E = \Delta m\, c^2$ $\Delta m = \frac{E}{c^2}$; $\Delta m = \frac{5.63 \times 1.6 \times 10^{-13}}{(3 \times 10^8)^2}$ $= 1.00088 \times 10^{-29}$ kg	**0.5** **0.5** **0.5**

Exercise 3 (6 points) Mars

Question		Answer	Mark
1		Mercury, Venus, Earth and Mars	**1**
2	2-1	It is a terrestrial planet	**0.5**
	2-2	The red planet	**0.5**
3	3-1	The period of revolution is the duration (or time needed) of one complete revolution of the planet around the Sun.	**1**
	3-2	$T_M = 1.881 \times 365.25 = 687.035$ days.	**1**
	3-3	$T_M = 1.881$ years $>$ $T_E = 1$ year Therefore, the Earth is closer to the Sun.	**0.5** **0.5**
	3-4	Statement of Kepler's 3rd law : The period of revolution of the planet increases with the average distance from the Sun.	**1**