

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

**Exercise 1: (7 1/2 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).

Take:

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

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

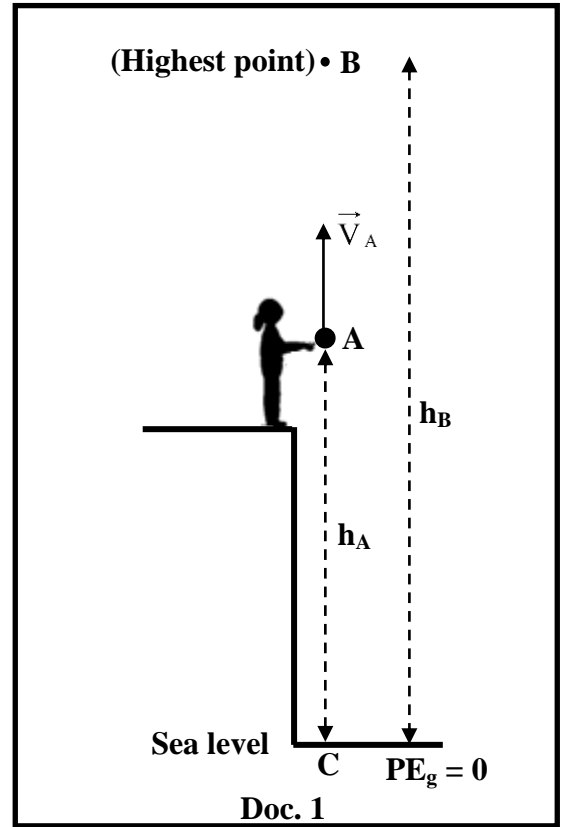
- 1-1) the kinetic energy of the stone;
- 1-2) the gravitational potential energy of the system [stone, Earth];
- 1-3) the mechanical energy of the system [stone, Earth].

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?



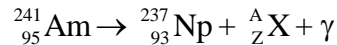
## **Exercise 2: (6 ½ points)**

### **The americium-241 nucleus**

The americium nucleus  ${}_{95}^{241}\text{Am}$  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  ${}_{95}^{241}\text{Am}$ .

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



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  ${}_Z^AX$ .

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

2-4-1) the cause of the emission of the  $\gamma$  radiation;

2-4-2) the nature of the  $\gamma$  radiation.

3- The energy liberated due to this disintegration of the americium-241 nucleus is  $E = 5.63 \text{ MeV}$ . Calculate, in kg, the mass defect  $\Delta m$  due to this disintegration.

Given:

$1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$  ; speed of light in vacuum  $c = 3 \times 10^8 \text{ m/s}$ .

## **Exercise 3: (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  $T_E = 1 \text{ year} = 365.25$  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).

Exercise 1: (7 points)

Mechanical energy

Part	Answer	Grade
1	1-1 $KE_{(A)} = \frac{1}{2} m V_A^2 = \frac{1}{2} \times 0.1 \times (12)^2 = 7.2 \text{ J}$	1
	1-2 $PE_{g(A)} = mgh_A = 0.1 \times 10 \times 30 = 30 \text{ J}$	1
	1-3 $ME_{(A)} = KE_{(A)} + PE_{g(A)} = 7.2 + 30 = 37.2 \text{ J}$	1
2	2-1 $ME_B = ME_A$ because air resistance is neglected Then, $ME_B = 37.2 \text{ J}$	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, $ME_B = PE_{g(B)} = mg h_B$ $37.2 = 0.1 \times 10 \times h_B$ ; $h_B = 37.2 \text{ m}$	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, $ME_C = KE_C = 37.2 \text{ J}$ $37.2 = \frac{1}{2} \times 0.1 \times V_C^2$ ; $V_C = 27.27 \text{ m/s}$	0.25 0.25 0.5
3	3-1 $ME_{\text{new}} = KE_{\text{new}} + PE_{(g) \text{ sea level}}$ But $PE_{(g) \text{ sea level}} = 0$ (On the reference level) $ME_{\text{new}} = \frac{1}{2} \times 0.1 \times (21)^2 = 22.05 \text{ J}$	0.5
	3-2 The mechanical energy decreases by: $ME_A - ME_C = 37.2 - 22.05 = 15.15 \text{ J}$	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 $Z = 95$	0.5
		The number of nucleons is $A = 241$	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)	0.25
		$241 = 237 + A$ , then $A = 4$ $95 = 93 + Z$ , then $Z = 2$	0.5 0.5
	2-3	Helium nucleus Symbol : ${}^A_ZX = {}^4_2\text{He}$	0.25 0.5
	2-4	2-4-1	Gamma radiation is emitted due to the downward transition (de-excitation) of the daughter nucleus ${}^{237}_{93}\text{Np}$
2-4-2		Electromagnetic radiation	0.5
3		$E = \Delta m c^2$	0.5
		$\Delta m = \frac{E}{c^2}$ ; $\Delta m = \frac{5.63 \times 1.6 \times 10^{-13}}{(3 \times 10^8)^2}$	0.5
		$= 1.00088 \times 10^{-29} \text{ kg}$	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 3 <sup>rd</sup> law : The period of revolution of the planet increases with the average distance from the Sun.