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

# مسابقة في الثقافة العلمية: مادة الفيزياء

## المدة: ساعة واحدة

(باللغة الإنكليزية)

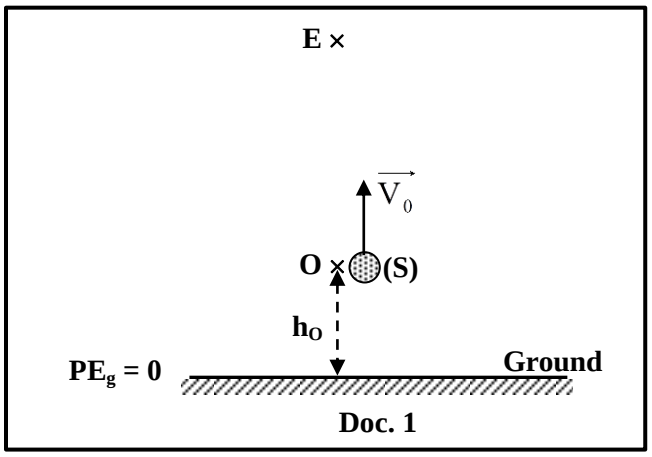
**الاسم: .....**

**الرقم: .....**

**Exercise 1 (7 points)**

## Mechanical energy

From a point O at a height $h_O$ above the ground, a stone (S), considered as a particle of mass m = 0.1 kg, is launched vertically upwards with an initial velocity $\overrightarrow{V_0}$ as shown in document 1.




Doc. 1

An appropriate device allows to register the gravitational potential energy ($PE_g$) of the system (stone – Earth) and the kinetic energy (KE) of the stone at the points O, A, B, C, D, and E during the upward motion of the stone. The results are tabulated in document 2.

Take:

- the ground as a reference level for gravitational potential energy;
- g = 10 m/s$^2$.

| | O | A | B | C | D | E |
|---|---|---|---|---|---|---|
| $PE_g$ (J) | 2 | 3 | 4 | 5 | 6 | 7 |
| KE (J) | 5 | 4 | 3 | 2 | 1 | 0 |

**Doc. 2**

**1- Indicate** the value of the gravitational potential energy of the system (stone – Earth) at O.

**2- Deduce** the initial height $h_O$.

**3- Determine** the magnitude $V_0$ of the velocity $\overrightarrow{V_0}$.

**4- Justify** that E is the highest point attained by (S).

**5- 1. Determine**, relative to the ground, the maximum height reached by (S).
**2**. Deduce the distance OE.

**6- 1. Calculate** the mechanical energy of the system (stone – Earth) at the points O, C, and E.
**2. Give** a conclusion.

**7- 1. Determine** the kinetic energy of (S) as it hits the ground.
**2. Deduce** the speed of (S) as it hits the ground.

**Exercise 2 (7 points)**

## Nuclear reactions: fission and fusion

The aim of this exercise is to show some of the advantages and the disadvantages of fission and fusion nuclear reactions.

### 1- Nuclear fission

The most commonly nuclide used in nuclear fission reactions is the uranium -235.

One of the possible nuclear reactions of **uranium -235** is the following:

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{90}_{36}\mathrm{Kr} + {}^{142}_{56}\mathrm{Ba} + \mathrm{y}\ {}^{1}_{0}\mathrm{n}\ .$$

Given: $1u = 1.66 \times 10^{-27}$ kg; Speed of light in vacuum: $c = 3 \times 10^{8}$ m/s.

**1.1) Calculate** the value of "y" indicating the used law.

**1.2) Justify** that this reaction leads to a chain reaction.

**1.3)** The mass defect that occurs during the above nuclear reaction is $\Delta m = 0.177755$ u.

**1.3.1) Calculate**, in Kg, the masse defect $\Delta m$

**1.3.2) Determine**, in Joules, the energy liberated by the fission of one nucleus of uranium-235.

**1.3.3)** The mass of one nucleus of uranium-235 is $3.9 \times 10^{-22}$ g.

**Show that** the energy liberated by the fission of 1 g of uranium-235 is $E_1 = 6.809 \times 10^{10}$ J.

## 2- Nuclear fusion

When a deuterium nucleus ${}^{2}_{1}H$ collides with a tritium nucleus ${}^{3}_{1}H$ at a high speed, they give a stable nucleus and a neutron, as in the following nuclear equation:

$$ {}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n . $$

The energy liberated by the fusion of 1 g by a mixture formed of ${}^{2}_{1}H$ and ${}^{3}_{1}H$ is

$$ E_2 = 3.42 \times 10^{11} J. $$

**2.1) Justify** that the above nuclear reaction is fusion.

**2.2) Why** the nuclei deuterium ${}^{2}_{1}H$ and tritium ${}^{3}_{1}H$ need a high speed to undergo fusion reaction?

**2.3) Indicate**, by comparing $E_2$ to $E_1$, which of the two nuclear reactions (fission or fusion) is more interesting.

## 3- Utilization

1. **Indicate** which one of the two nuclear reactions (fission or fusion) is used in the production of electric energy.
2. **Justify** your answer.

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

## Celestial events in 2018

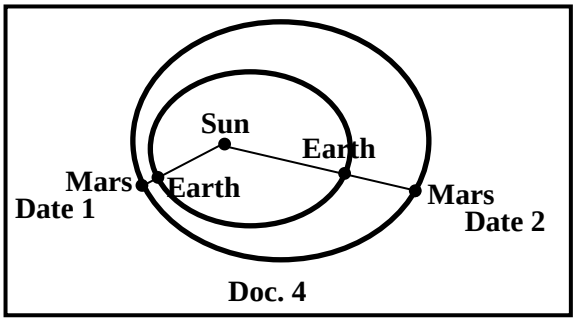
During the year 2018 many celestial events are expected, including Mars at opposition and nighty shooting stars.

- **Mars at opposition (friday, July 27)**
  Mars is at opposition when the Sun, Earth, and Mars are aligned in this order. On friday, July 27, Mars will be very easily observable in the sky, since its distance to the Earth will be minimal.
  Mars' opposition occurs approximately every two years, as Mars revolves around the Sun in an orbit
  larger than that of the Earth. A Martian year (Mars' year) is thus almost twice as long as a terrestrial year.
- **Nighty shooting stars (the night of 11$^{th}$ - 12$^{th}$ August)**
  As every year, the orbit of the Earth will cross the clouds of cometary dust scattered by the comet "Swift-Tuttle". As they enter the Earth's atmosphere, the dust will burn and give us a stream of shooting stars.

**According to the website ''Sciences et avenir''**

**Doc.3**

Document 4 represents a simplified diagram of the trajectories of the Earth and Mars around the Sun, as well as Mars' opposition at two different dates (date 1 and date 2).




**Doc. 4**

**1- Indicate** the two events and the date of each one that are mentioned in document 3.

**2- Indicate** the shape of the trajectories described by the planets around the Sun in document4.

**3- Pick out** from document 3 the expression that justifies that on July 27, 2018, Mars' opposition corresponds to date 1 and not to date 2.

**4- Pick out** from document 3 the statement that permits to conclude that the Martian year is almost double than the Earth's year.

**5-** Document 3 mentions the comet "Swift-Tuttle".

**4.1) Name** the three main parts of a comet.

**4.2) Indicate** the part of a comet that contains cemetery dust.

**4.3) Explain** the process of formation of shooting stars, using the information in document 3.