مسابقة في الثقافة العلمية: مادة الفيزياء
المدة ساعة واحدة

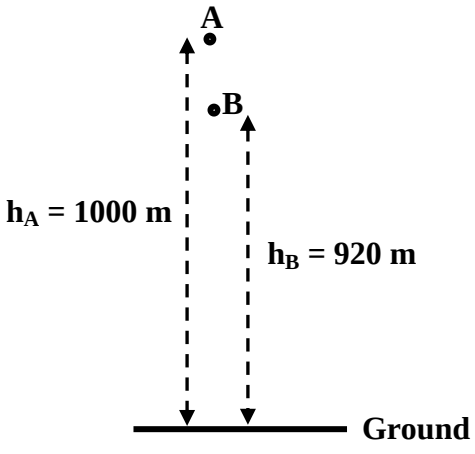
الاسم:
الرقم:

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

## First exercise: (7 points)

### The fall of a parachutist

A parachutist (S), of total mass M = 100 kg, falls without initial velocity from a stationary helicopter at an altitude of $h_A$ = 1000 m. When the parachutist reaches a speed of 40 m/s at an altitude $h_B$ = 920 m, he opens his parachute and then reaches the ground with a speed of 6 m/s.




**Take:**

- the horizontal plane passing through the ground as a gravitational potential energy reference ($P.E_g = 0$);
- $g = 10\ m/s^2$.

**1)** The parachutist is at the altitude $h_A$ = 1000 m.
  **a)** Calculate the gravitational potential energy of the system [(S), Earth].
  **b)** Determine the mechanical energy of the system [(S), Earth].

**2)** The parachutist is at the altitude $h_B$ = 920 m.
  **a)** Calculate the gravitational potential energy of the system [(S), Earth].
  **b)** Calculate the kinetic energy of (S).
  **c)** Deduce the mechanical energy of the system [(S), Earth].

**3)** Determine the mechanical energy of the system [(S), Earth] when (S) reaches the ground.

**4)** **a)** Specify in which phase of fall, before or after opening the parachute, there is a loss of mechanical energy.
  **b)** In what form of energy, does this loss appear?

## Second exercise: (7 points)

### Scintigraphy

**Given:**

| | | |
|---|---|---|
| $m(^{198}_{79}Au) = 197.9248$ u | $m(^{A}_{Z}Hg) = 197.9228$ u | $m(^{0}_{-1}e) = 5.5\times10^{-4}$ u |
| speed of light in vacuum: $c = 3\times10^8$ m/s | $1\ u = 1.66\times10^{-27}$ kg | |

The gold ($^{198}_{79}Au$) is a $\beta^-$ emitter. It disintegrates according to the following reaction :

$$^{198}_{79}Au \rightarrow {}^{A}_{Z}Hg + {}^{0}_{-1}e + \gamma$$

**1)** **a)** Indicate the nature of the radiation $\gamma$.
  **b)** Determine Z and A in the above reaction, indicating the laws used.

**2)** Determine, in joule, the energy E liberated by the disintegration of one nucleus of gold 198.

**3)** In a scintigraphy session for a liver failure, the patient is injected by a small quantity of gold 198 containing $n = 3 \times 10^{12}$ nuclei. Show that the energy liberated by the disintegration of the n nuclei of gold 198 is $E_1 \approx 0.65$ J.

**4)** **a)** Calculate the energy E' absorbed by the liver knowing that $E' = \frac{E_1}{2}$.

**b)** Calculate the absorbed dose by the liver whose mass is 0.75 kg.

**c)** Deduce, in sievert (Sv), the physiological equivalent of dose (ED) knowing that the Relative Biological Efficiency of this radiation is R.B.E = 1.

**<u>Third exercise</u>: (6 points)**

**Scientists**

**Read carefully the following text and answer the question**

**«**Tycho Brahe invented several measuring instruments with which he performed invaluable observations with the naked eye. Johannes Kepler, assistant of Tycho Brahe, used the data of positions collected by Tycho Brahe and published the three empirical laws of the planetary motion… Later on, Issac Newton stated a universal law that confirmed the three laws of Kepler …»

**Questions**

**1)** Pick up from the text the statement that shows the contribution of Tycho Brahe in astronomy.

**2)** Earth and Saturn , two planets, revolve around the Sun. The average distance ($d_E$) between the Earth and the Sun is less than the average distance ($d_S$) between Saturn and the Sun.
Compare, with justification, the period of revolution of the Earth ($T_E$) to that of Saturn ($T_S$) according to Kepler's third law.

**3)** Indicate the form of the trajectories described by the planets around the Sun, according to Kepler's first law.

**4)** State Kepler's second law.

**5)** **a)** Name the law established by Issac Newton that confirms the three laws of Kepler.
**b)** State this law.

**6)** Name a scientist not mentioned in the text that contributed to the development of astronomy in the $16^{th}$ and $17^{th}$ century.

| | | |
|---|---|---|
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## First exercise: (7 points)

| Part | Answer | Mark |
|---|---|---|
| 1.a | $PE_g\ (A) = Mgh_A$<br>$\Rightarrow PE_g\ (A) = 100\times10\times1000 \Rightarrow PE_g\ (A) = 1000000$ J | 1 |
| 1.b | $ME(A) = KE(A) + PE_g(A)$<br>But the $KE(A) = 0$ (falls without of initial velocity)<br>$\Rightarrow ME(A) = 1000000$ J | 11/2 |
| 2.a | $PE_g\ (B) = Mgh_B$<br>$\Rightarrow PE_g\ (B) = 100\times10\times920$<br>$\Rightarrow PE_g\ (B) = 920000$ J | 1/2 |
| 2.b | $KE(B) = \frac{1}{2}\ MV^2$<br>$\Rightarrow KE(B) = \frac{1}{2}\times100\times(40)^2$<br>$\Rightarrow KE(B) = 80000$ J | 1 |
| 2.c | $ME(B) = KE(B) + PE_g(B) \Rightarrow ME(B) = 1000000$ J | 1 |
| 3 | $ME_{Ground} = KE_{Ground} + PE_{g(Ground)}$<br>$PE_{g(Ground)} = 0$ (on the reference)<br>$KE_{Ground} = \frac{1}{2}\ M\ V^2_{Ground} \Rightarrow KE_{Ground} = \frac{1}{2}\times100\times(6)^2$<br>$\Rightarrow KE_{Ground} = 1800$ J $\Rightarrow ME(A) = 1800$ J | 1 |
| 4.a | After opening, because $ME(B) > ME_{Ground}$ | 1/2 |
| 4.b | Heat or thermal energy. | 1/2 |

**<u>Second exercise</u>: (7 points)**

| Part | Answer | Mark |
|---|---|---|
| **1.a** | Electromagnetic radiation | 1/2 |
| **1.b** | Conservation of mass number: A = 198<br><br>Conservation of charge number: Z = 80 | 1 |
| **2** | $\Delta m = m_{before} - m_{after}$<br><br>$\Rightarrow \Delta m = 197.9248 - (197.9228 + 5.5\times10^{-4})$ u<br>$\Rightarrow \Delta m = 1.45\times10^{-3}$ u<br>$\Rightarrow \Delta m = 1.45\times10^{-3}\times 1.66\times10^{-27} = 2.407 \times 10^{-30}$ kg<br><br>$E = \Delta m.c^2 = 2.407\times10^{-30}\times 9 \times10^{16} = 2.16\times10^{-13}$ J | 2 |
| **3** | $E_1 = 2.16\times 10^{-13} \times 3\times 10^{12} = 0.648$ J | 1 |
| **4.a** | E' = 0.648×0.5 = 0.324 J | 1/2 |
| **4.b** | $D = \frac{E}{M} = \frac{0.324}{0.75} \approx 0.432$ Gy. | 1 |
| **4.c** | ED = D×R.B.E = 0.432×1 = 0.432 Sv. | 1 |

**<u>Third exercise</u>: (6 points)**

| Part | Answer | Mark |
|---|---|---|
| **1** | Tycho Brahe invented several measuring instruments with which he performed invaluable observations with the naked eye. | 1 |
| **2** | $T_S > T_E$ since $d_S > d_E$<br><br>because according to Kepler's third law : as the average distance between the planet and the sun increases , the period of revolution of the planet increases | 1 |
| **3** | Ellipse | 1/2 |
| **4** | The speed of the planet decreases as the distance between the planet and the sun increases. | 1 |
| **5.a** | Law of universal gravitational. | 1/2 |
| **5.b** | Any two bodies attract each other with a force that varies with the inverse of the square of the distance between them and with the product of their masses | 11/2 |
| **6** | Galileo Galilei | 1/2 |