مسابقة في الثقافة العلمية: مادة الفيزياء
المدة: ساعة واحدة

الاسم:
الرقم:

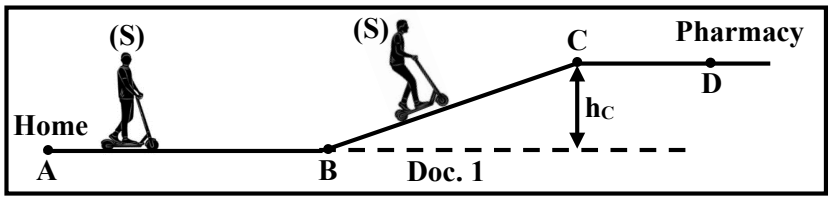
This exam is formed of three obligatory exercises in two pages.
The use of non-programmable calculator is recommended.

Exercise 1 (7 pts)

Electric scooter

Every morning, Sam uses his electric scooter to go from his home to the pharmacy where he works. Sam and his scooter are considered as a particle (S) of mass of m = 80 kg.

He starts from rest at his home, located at point A, and moves along a horizontal road AB. He reaches point B with a speed of V_B = 5 m/s. From B, he ascends at constant speed V_B up an inclined slope to point C, located at an altitude h_C = 1.5 m. After C, he continues on a horizontal path and finally comes to a stop next to his pharmacy at point D (Doc.1).



Take :

- the horizontal plane passing through point A as the reference level for the gravitational potential energy of the system [(S), Earth];
- g = 10 m/s^2.

1) Calculate the mechanical energies ME_A and ME_B of the system [(S), Earth] at A and B, respectively.

2) Deduce the value of the mechanical energy gained between A and B.

3) The gain in this mechanical energy comes from the electrical energy supplied by the scooter's battery. Knowing that 25% of the electrical energy is converted into mechanical energy, calculate the electrical energy provided by the scooter's battery between A and B.

4) Choose with justification the correct answer.

4.1) When Sam moves from B to C, his kinetic energy KE:

a) remains the same **b)** decreases **c)** increases

4.2) The gravitational potential energy GPE of the system [(S), Earth] at point C is:

a) GPE_C = 1800 J **b)** GPE_C = 1200 J **c)** GPE_C = 9600 J

4.3) When Sam moves from C to D:

a) KE increases and GPE decreases.
b) KE decreases and GPE increases.
c) KE remains the same and GPE remains the same.
d) KE decreases and GPE remains the same.

5) Indicate one environmental advantage of using an electric scooter to go to the pharmacy instead of using public transportation.

Exercise 2 (6.5 pts)

Bicycle dynamo

Read carefully document 2, then answer the questions:

« A dynamo is a device usually located on a bicycle wheel that converts a part of the energy generated by the wheel's rotation into electrical energy. This energy is then used to light the front and rear lamps of the bicycle, thus providing continuous lighting without using batteries. »

According to the website: www.gravelrepublic

Doc. 2

Questions

1) Document 2 mentions two energy converters: the dynamo and the lamps. Indicate:

- the form of the energy E_1 consumed by the dynamo;
- the form of the energy E_2 consumed by the lamps;
- the form of the useful energy E_3 furnished by the lamps.

2) A person rides his bicycle at night and travels for 20 minutes to get home. The dynamo, equipped by an appropriate device, produces a constant current I = 0.5 A under a voltage U = 6 V.

2.1) Calculate the useful electric energy «$E_{electric}$ » produced by the dynamo during these 20 minutes.

2.2) The efficiency « r » of the dynamo is : $r = \frac{\text{useful energy}}{\text{received energy}} = 60\%$

Calculate the energy received by the dynamo during these 20 minutes.

2.3) Calculate the dissipated energy during this energy conversion in the dynamo.

2.4) In what form is this energy dissipated?

3) Pick out from document 2, one advantage of using a dynamo for lighting.

Exercise 3 (6.5 pts)

Marie Curie and radioactivity

Read carefully document 3 then answer the questions:

Marie Curie is best known for her groundbreaking work on radioactivity.
In 1896, Henry Becquerel first discovered that uranium salts emitted their own radiation without any need for excitation […]. Marie Curie then explored, alongside her husband Pierre Curie, two new radioactive elements, radium and polonium, in 1898. This research paved the way for numerous medical and industrial applications of radioactivity.
Unfortunately, long exposure to radiation had harmful effects on her health. At her death in 1934, her body was believed to be so radioactive that she had to be buried in a lead-lined[1] coffin[2]. Even today, many of her belongings remain highly radioactive. These items are stored in lead boxes at the National Library of France in Paris. Visitors requesting access are required to sign a liability waiver and wear protective clothing to avoid exposure to radium-226. And the situation isn't expected to change anytime soon, as this particular isotope has a half-life of around 1600 years.

According to the website: https://sciencepost.fr/

1. lead-lined: covered or lined with lead.
2. coffin: a box, usually made of wood or metal, in which a body is placed for burial.

Doc. 3

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

Questions

1) Pick out from document 3 the expression that shows uranium is a radioactive substance.

2) One of the two elements discovered by Pierre and Marie Curie is polonium-210 ($^{210}_{84}Po$).
Indicate the composition of this nucleus.

3) The radioactive isotope of radium $^{226}_{88}Ra$ decays into radon Rn with the emission of an alpha particle, according to the equation:

$$^{226}_{88}Ra \rightarrow {}^{A}_{Z}Rn + \alpha$$

3.1) Indicate the name and the symbol of the α particle.

3.2) Calculate A and Z, indicating the laws used.

3.3) The decay of one nucleus of radium $^{226}_{88}Ra$ liberates an energy of E_{lib} = 4.881 MeV.
Calculate this energy in joules.

3.4) Deduce the mass defect Δm corresponding to this decay.

3.5) This decay is accompanied by the emission of a very penetrating gamma radiation (γ).

3.5.1) Indicate the cause of this emission.

3.5.2) Justify the use of lead for Marie Curie's coffin and for storing her belongings.

3.6) According to document 3, the half-life of radium-226 is about T = 1600 years.
Determine the duration during which the mass of radium-226 in her belongings becomes $\frac{1}{4}$ of its actual value m_0.

مسابقة في مادة الفيزياء
أسس التصحيح - إنكليزي

Exercise 1 (7 pts)	**Electric Scooter**	
part	**Answer**	**grade**
1	$ME_A = KE_A + GPE_A$ $ME_A = 0 + 0 \quad = 0$ J $ME_B = KE_B + GPE_B$ $ME_A = ½\ m\ V_B^2 + 0$ $ME_A = ½\ 80 \times 5^2 \quad = 1\ 000$ J	**0.5** **1**
2	Mechanical energy gained **= 1000 – 0 = 1000 J**	**0.5**
3	25% Eelectric = ME ; $E_{electric} = ME \times \frac{100}{25} = 4000$ J	**1**
4.1	**a)** remains the same Because between B and C the speed is constant ($KE = ½\ m\ V^2$ and the mass is constant).	**1**
4.2	b) $GPE_C = m \times g \times h_C = 80 \times 10 \times 1.5 = 1\ 200$ J	**1**
4.3	d) KE decreases and GPE remains the same. Because Sam's speed decreases to stop, So KE decreases. GPE remains the same because his height relative to the reference level does not change. Mass (m) and gravitational field strength (g) remain constant.	**1**
5	**<u>One advantage:</u>** - Reducing greenhouse gas emissions. - Lowering carbon dioxide emissions. - Reducing smog formation. - Decreasing the consumption of non-renewable energy sources. - Reducing noise pollution.	**1**

Exercise 2 (6.5 pts)	**Bicycle Dynamo**	
part	**Answer**	**grade**
1	Energy E_1 consumed by the dynamo: kinetic energy from the rotation of the wheels Energy E_2 consumed by the lamps: electrical energy Useful energy E_3 provided by the front and rear lamps: light energy	**0.5** **0.5** **0.5**
2.1	$E_{electric} = U \times I \times t = 6 \times 0.5 \times 20 \times 60 = 3600$ J	**1**
2.2	$r = \frac{\text{Useful energy}}{\text{Consumed energy}} = 60\%$; $E_1 = \frac{\text{Useful energy}}{60\%} = 6\ 000$ J	**1**
2.3	Dissipated energy $= 6000 - 3600 = 2400$ J	**1**
2.4	Thermal energy	**1**
3	Providing continuous lighting without using batteries	**1**

Exercise 3 (6.5 pts)	Marie Curie and radioactivity	
part	**Answer**	**grade**
1	Uranium salts emitted their own radiation without any need for excitation	**1**
2	$^{210}_{84}Po$ Number of protons Z = 84 Number of neutrons N = 210 – 84 = 126	**0.25** **0.5**
3.1	Name: Helium nucleus Symbol : $^{4}_{2}He$	**0.25** **0.25**
3.2	The law of conservation of mass number: 226 = A + 4 ; A = 222 The law of conservation of charge number: 88 = Z + 2 ; Z = 86	**0.5** **0.5**
3.3	$E_{lib} = 4.881 \times 1.6 \times 10^{-13} = 7.8096 \times 10^{-13}$ J	**0.5**
3.4	$E_{lib} = \Delta m \times c^2$; $\Delta m = \frac{7.8096 \times 10^{-13}}{(3 \times 10^8)^2} = 8.677 \times 10^{-30}$kg	**1**
3.5.1	Gamma radiation (γ) is emitted during the de-excitation of the radon-formed nucleus.	**0.5**
3.5.2	Since the γ radiations have a high penetrating power, so we use lead in order to stop the emitted γ radiations.	**0.5**
3.6	$m_0 \rightarrow \frac{m_0}{2} \rightarrow \frac{m_0}{4}$ then t = 2 T = 2 × 1600 = 3 200 years	**0.75**