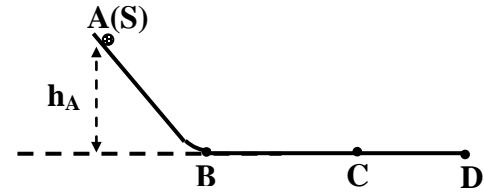**This exam is formed of three exercises in two pages**
The use of non-programmable calculators is allowed

First exercise (7 points)

Mechanical energy

Consider the track ABCD situated in a vertical plane and
represented in the adjacent figure.
A solid point mass (S) of mass m = 2 kg, is released, without
initial velocity, from point A at a height h_A = 5 m above the
horizontal level BCD of the track.
Take the horizontal plane through BCD as a gravitational potential
energy reference for the system [(S) , Earth].
Neglect all friction on the inclined part AB of the track. Take g = 10 m/s^2.

1) **a)** Calculate the value of the gravitational potential energy of the system [(S), Earth] at A.
b) Deduce the value of the mechanical energy of the system [(S), Earth] at A.
2) The mechanical energy of the system [(S), Earth] between A and B is conserved. Why ?
3) Using the law of conservation of the mechanical energy between A and B:
a) determine the value of the kinetic energy of (S) at B;
b) verify that the speed of (S) at B is 10 m/s.
4) After leaving point B, (S) reaches point C with the speed of 6 m/s.
a) Calculate the value of the mechanical energy of the system [(S), Earth] at C.
b) Show the existence of a frictional force on the part BC of the track.

Second exercise (7 points)

Nuclear fusion

Consider the following nuclear reaction:

$$_1^2H + {}_1^3H \longrightarrow {}_2^4He + {}_Z^AX$$
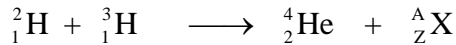
This reaction is an example of nuclear fusion that liberates energy without producing nuclear wastes.
If we can achieve a fusion reactor, we will have a clean and inexhaustible energy source because hydrogen is
very abundant in nature. The current technology cannot allow us to construct and operate such a reactor.
We utilize the energy liberated by a natural nuclear fusion reactor which is at a distance 150×10^6 km from the
Earth.

Given:

Masses of nuclei: $(^2_1H) = 2.013$ u ; $(^3_1H) = 3.015$ u ; $(^4_2He) = 4.002$ u.

Mass of the particle $(^A_Z X) = 1.008$ u.

$1u = 1.66 \times 10^{-27}$ kg; $c = 3 \times 10^8$ m/s.

1) **a)** Determine Z and A and indicate the used laws.
   b) Specify the nature of the particle $^A_Z X$.
2) **a)** Calculate, in u and then in kg, the mass defect of this reaction.
   b) Deduce, in joule, the value of the energy liberated by this reaction.
3) A fusion reactor is a clean and inexhaustible source of energy. From the text, justify these two properties.
4) What is the major problem that results from production of energy in the current nuclear power plants?
5) In the text we read: a natural nuclear fusion reactor which is at a distance 150×10^6 km from the Earth.
   a) What reactor are we talking about?
   b) Name two convertors allowing us to utilize the liberated energy of this reactor.

Third exercise (6 points)
Pluto and Mars

Read carefully the following selection then answer the questions that follow:

«…Pluto, the ninth planet of the solar system is the farthest of the outer planets. On the other hand, Mars, the fourth planet of the solar system is also the farthest of the inner planets….
Pluto was discovered in 1930 and was known in 1978 to have only one moon. The telescope Hubble has just discovered two more moons of Pluto which were thought of as asteroids of the Kuiper belt that extends many light years beyond the limits of our solar system.
Mars is called the red planet due to the amount of iron oxide in its crust, and its atmosphere is mainly formed of carbon dioxide ….»

Questions
1) In the text, we read about two groups of the planets of our solar system. Name two planets of each group other than that mentioned in the text.
2) Give the name of one planet having one moon, and another one having many moons.
3) In the text, we read about asteroids of Kuiper belt.
   a) What is an asteroid?
   b) A moon rotates around a planet. About what an asteroid rotates?
   c) An asteroids belt, other than that of Kuiper, exists in our solar system. Specify its position.
4) Pick up from the text:
   a) an indicator that shows life seems to be impossible on Mars;
   b) the reason for which Mars is called a "red planet".

First exercise (7 points)

Part of the Q	Answer	Mark
1.a	$PE_{gA} = mgh_A = 100$ J	1
1.b	$ME_A = KE_A + PE_{gA}\ 0 + 100 = 100$ J	1
2	ME is conserved since friction is neglected	1
3.a	$ME_A = KE_B + PE_{gB} = KE_B + 0 = ME_A \Rightarrow KE_B = 100$ J	1
3.b	$KE_B = \frac{1}{2} mV^2_B = 100$ J; $\Rightarrow V_B = 10$ m/s	1
4.a	$PE_{gC} = 0$ thus $ME_C = KE_C + 0 = \frac{1}{2} mV^2_C = 36$ J	1
4.b	$M.E_C \neq M.E_B$ thus M.E is not conserved $\Rightarrow$ there exist a force of friction.	1

Second exercise (7 points)

Part of the Q	Answer	Mark
1.a	$^2_1H + ^3_1H \longrightarrow ^4_2He + ^A_ZX$ Soddy laws: A =1 and Z = 0 ;	1.5
1.b	$^1_0X = ^1_0n$ it is a neutron	0.5
2.a	$\Delta m = m_{before} - m_{after} = 0.018$ u $\approx 3\times10^{-29}$ kg	1
2.b	$E = \Delta m\ c^2 = 2.7 \times10^{-12}$ J.	1
3	Clean : No production of nuclear waste Inexhaustible: Hydrogen is more abundant in nature	1
4	Production of nuclear wastes.	0.5
5.a	Sun	0.5
5.b	Solar panels, solar cells.	1

Third exercise (6 points)

Part of the Q	Answer	Mark
1	Inner group: Mercury, Earth, Venus and Mars. Outer group: Jupiter, Saturn, Uranus, Neptune and Pluto.	1
2	Earth has one moon. Mars, Jupiter, Saturn, Uranus, Neptune Pluto, each has many moons	1
3.a	The asteroid is a rocky of irregular shape.	1
3.b	The asteroids rotate around the Sun	1
3.c	This belt is found between the orbit of Mars and the orbit of Jupiter	1
4.a	Atmosphere of Mars is mainly carbon dioxide	0.5
4.b	Mars seems red due to the presence of iron oxide in its crust	0.5