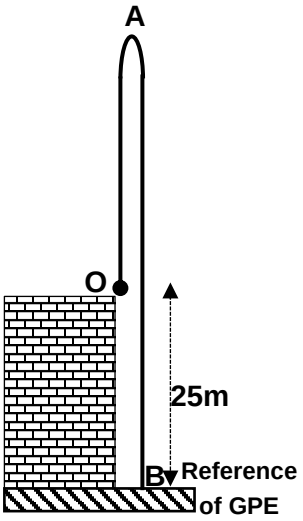
مسابقة في مادة الفيزياء
المدة: ساعة واحدة

الاسم:
الرقم:

The exam is formed of three exercises.
The use of non-programmable calculators is recommended.

I-(08 points)
Mechanical Energy

From a point O, found at $25m$ above the ground, Tarek throws a stone (S), of mass $0.1kg$, vertically upwards with a speed of $20m/s$.
(S) thus reaches a highest point A then falls down to the ground at B.
Neglect air resistance and take $g = 10m/s^2$.
The horizontal level of the ground B is taken as the gravitational potential energy reference for the system [(S), Earth].



1. Calculate, at the instant of shooting at point O:
   a) the kinetic energy of (S).
   b) the gravitational potential energy of the system [(S), Earth].
   c) the mechanical energy of the system [(S), Earth].
2. a) The mechanical energy of the system [(S), Earth] is conserved. Why?
   b) What is the speed of (S) at the highest point A? Deduce the kinetic energy of (S) at A.
   c) Determine the gravitational potential energy of the system [(S), Earth] at A and deduce the height of A above the ground.
3. (S) meets the ground at B. Determine, using the conservation of mechanical energy, the kinetic energy and the speed of (S) at B.

II-(06 points)
Nuclear Fusion

In young stars, as our Sun, two hydrogen nuclei (^1_1H) fuse to form deuterium nucleus (^2_1H). Two deuterium nuclei fuse to give a tritium (^3_1H). However, from the energetic point of view, the most interesting fusion reaction is that one corresponding to a deuterium nucleus (^2_1H) and a tritium nucleus (^3_1H). This reaction produces a helium nucleus (^4_2He) and a neutron.

Given the masses of the nuclei in the atomic mass unit:

- $m(^1_1H) = 1.0073u$; $m(^2_1H) = 2.0136u$;
- $m(^3_1H) = 3.0155u$; $m(^4_2He) = 4.0015u$; $m(^1_0n) = 1.0087u$;

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

Questions:

1. (^1_1H), (^2_1H), and (^3_1H) are isotopes of the same element. Why?
2. What is the number of neutrons in the tritium nucleus?
3. The first fusion reaction described in the text is of form: $^1_1H + ^1_1H \longrightarrow ^2_1H + ^A_ZX$
   Determine A and Z and give the name of X.

4. One of the reactions mentioned in the text produces a helium nucleus (^4_2He).
   a) Write the corresponding equation of the reactions.
   b) Calculate, in u then in kg, the mass defect in this reaction.
   c) Calculate, in joules, the energy liberated by this reaction.

III-(06 points)
Solar System

Certain characteristics of the planets of our solar system are summarized in the following table:

Planet	Average distance from the Sun (AU)	Speed of the planet along its orbit (km/s)	One revolution around the Sun (year)	Density (g/cm^3)	Chemical composition of the atmosphere	Surface temperature (^0C)
Mercury	0.38	47.9	?	5.43	H_2, He	-170 to 400
Venus	0.72	35	0.61	5.24	CO_2 (95%)	480
Earth	1	29.8	1	5.51	N_2, O_2	22
Mars	1.52	24.1	1.88	3.94	CO_2	-170 to 35
Jupiter	5.20	13.1	11.86	1.33	H_2, He	-150
Saturn	9.53	9.6	29.45	0.69	H_2, He, CH_4	-180
Uranus	19.19	6.8	84	1.30	H_2, He, CH_4	-500
Neptune	30	5.4	164	1.76	H_2, He, CH_4	-210
Pluto	39.53	4.8	247.7	2	N_2	-230

Questions:

1. Scientists classify the planets into two groups: the internal group and the external group.
   The planets: **Mercury**, **Venus**, **Earth**, and **Mars** form a group.
   a) Which group?
   b) Point out, from the table, a physical quantity that characterizes their constitution.
2. The time taken by a planet to perform one complete revolution around the Sun is expressed in "years".
   What does "year" stand for? Justify your answer using the table.
3. The distance **Earth-Sun**, of value $150 \times 10^6 km$, is called the astronomical unit (AU).
   Calculate, in km, the distance **Uranus-Sun**.
4. Compare the temperature at the surface of **Mercury** and of **Venus** and their average distances from the Sun, answer the following questions:
   a) What is the strange observation noted about **Venus**?
   b) Due to what is this observation?
5. What conclusion may be drawn as a result of comparing:
   a) The period of revolution of the planets with their average distance from the **Sun**?
   b) The speeds of the planets with their average distances from the **Sun**?

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مشروع معيار التصحيح	مسابقة في مادة الفيزياء المدة ساعة	الاسم: الرقم:

First Exercise (8 points)

Part	Answer	Mark
1.a	$\mathrm{K.E_O} = \frac{1}{2}\mathrm{mV_O^2} = \frac{1}{2}(0.1)(20)^2 = 20\mathrm{J}$	1
1.b	$\mathrm{G.P.E_O} = \mathrm{mgh} = (0.1)(10)(25) = 25\mathrm{J}$	1
1.c	$\mathrm{M.E_O} = \mathrm{K.E_O} + \mathrm{G.P.E_O} = 20 + 25 = 45\mathrm{J}$	1
2.a	M.E is conserved since there is no air resistance.	0.25
2.b	$\mathrm{V_A} = 0\mathrm{m/s}$ then $\mathrm{K.E_A} = \frac{1}{2}\mathrm{mV_A^2} = 0\mathrm{J}$	2
2.c	By applying the law of conservation of mechanical energy: $\mathrm{M.E_o} = \mathrm{M.E_A} \Longrightarrow 45 = \mathrm{K.E_A} + \mathrm{G.P.E_A}$ ($\mathrm{K.E_A} = 0\mathrm{J}$ maximum position) $\mathrm{G.P.E_A} = 45\mathrm{J} \Longrightarrow \mathrm{G.P.E_A} = \mathrm{mgh_A} \Longrightarrow \mathrm{h_A} = \frac{\mathrm{G.P.E_A}}{\mathrm{mg}} = \frac{45}{0.1\times10} = 45\mathrm{m}$	2
3	By applying the law of conservation of mechanical energy: $\mathrm{M.E_o} = \mathrm{M.E_B} \Longrightarrow 45\mathrm{J} = \mathrm{K.E_B} + \mathrm{G.P.E_B}$ ($\mathrm{G.P.E_B} =$ $0\mathrm{J}$ since B is on the reference) $K.E_B = 45J \Longrightarrow \frac{1}{2}mv_B^2 = 45 \Longrightarrow \frac{1}{2}(0.1)v_B^2 = 45 \Longrightarrow v_B = 30m/s$	2.25

Second Exercise (8 points)

Part	Answer	Mark
1	They are isotopes of the element hydrogen since they are nuclides that have the same charge number Z=1 and different mass number A.	0.5
2	$\mathrm{N} = \mathrm{A} - \mathrm{Z} = 3 - 1 = 2$	0.50
3	By applying the law of conservation of the mass number: $1 + 1 = 2 + A \Longrightarrow A = 0$ By applying the law of conservation of the charge number: $1 + 1 = 1 + \mathrm{Z} \Longrightarrow \mathrm{Z} = 1$ Then the particle X is positron ${}_{+1}^{0}\mathrm{e}$	1.5
4.a	The equation can be written as: ${}_{1}^{2}\mathrm{H} + {}_{1}^{3}\mathrm{H} \rightarrow {}_{2}^{4}\mathrm{He} + {}_{\mathrm{Z}}^{\mathrm{A}}\mathrm{X}$ By applying the law of conservation of the mass number: $2 + 3 = 4 + A \Longrightarrow A = 1$ By applying the law of conservation of the charge number: $1 + 1 = 2 + Z \Longrightarrow Z = 0$ Then the particle X is a neutron ${}_{0}^{1}n$ Fusion reaction ${}_{1}^{2}\mathrm{H} + {}_{1}^{3}\mathrm{H} \rightarrow {}_{2}^{4}\mathrm{He} + {}_{0}^{1}\mathrm{n}$	0.5
4.b	$\Delta\mathrm{m} = \mathrm{m_b} - \mathrm{m_a} = [\mathrm{m}({}_{1}^{2}\mathrm{H}) + \mathrm{m}({}_{1}^{3}\mathrm{H})] - [\mathrm{m}({}_{2}^{4}\mathrm{He}) + \mathrm{m}({}_{0}^{1}\mathrm{n})]$ $= [2.0136\mathrm{u} + 3.0155\mathrm{u}] - [4.0015\mathrm{u} - 1.0087\mathrm{u}]$ $= 0.0189\mathrm{u} = 0.0189 \times 1.66 \times 10^{-27} = 3.137 \times 10^{-29}\mathrm{kg}$	1.75
4.c	$\mathrm{E} = \Delta\mathrm{mc}^2 = (3.137 \times 10^{-29})(3 \times 10^{8})^2 = 28.237 \times 10^{-13}\mathrm{J}$	1.25

Third Exercise (6 points)

Part	Answer	Mark
1.a	Inner planets or terrestrial planets	0.5
1.b	From the table, the planets Mercury, Venus, Earth, and Mars have respectively as densities 5.43; 5.24; 5.57 and 3.94 g/cm^3. The density being almost the same for the 4 planets, we can then consider it as characteristic physical quantity of the inner planets.	0.5
2	In the table, the duration of revolution of Earth around the Sun is equal to one unit. Thus, the year that is taken as unit is the Earth year.	1.25
3	Distance Uranus-Sun=19.9AU=$19.9\times150\times10^6=2.985\times10^9$km	1
4.a	From the table, we notice that the temperature of the surface of Venus is higher than that of the surface of Mercury although Venus is farther from the Sun than Mercury.	0.75
4.b	Atmosphere of Venus made up of carbon dioxide which causes Greenhouse effect whereas Mercury's atmosphere is thin and greenhouse effect doesn't take place.	0.5
5.a	From the table, the period of a planet around the Sun increases when the distance of this planet from the Sun increases.	0.75
5.b	From the table, the speed of a planet around the Sun increases when the distance of this planet from the Sun decreases.	0.75