國立成功大學

115學年度碩士班招生考試試題

編　號：45

系　所：太空與電漿科學研究所

科　目：普通物理

日　期：0204

節　次：第 1 節

注　意：1.不可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

- **Calculators NOT allowed.**
- **Derivation processes and explanations have to be given.**
- **Information you may need:**
  - **The mass of D (Deuterium) is 2.0141 u.**
  - **The mass of T (Tritium) is 3.0160 u.**
  - **The mass of α (Helium nucleus) is 4.0026 u.**
  - **The mass of n (neutron) is 1.0086 u.**
  - **The mass of p (proton) is 1.0073 u.**
  - **Atomic mass unit $u = 1.66 \times 10^{-27}$ kg.**
  - **The mass of e^- (electron) is 9.1094×10^{-31} kg.**
  - **The speed of light $c = 3 \times 10^8$ m/s.**
  - **Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}.**

1. (20 % in total) **People try to use nuclear fusion as the energy source. The following nuclear fusion reaction has the highest cross section:**

$$D + T \rightarrow \alpha + n$$

where D (^2_1H) and T (^3_1H) are deuterium and tritium, respectively, both are hydrogen isotopes, α is helium nucleus, and n is neutron.

   (a) **Please show why the above nuclear reaction generates energy.** (5 %)

   (b) **Please calculate how much energy is generated in one reaction based on Albert Einstein's famous equation $E = mc^2$ where E represents the energy in Joules, m is the mass in kg, and c is the speed of light in m/s.** (15 %)

2. (15 % in total) **People try to use deuterium (D, ^2_1H) and tritium (T, ^3_1H), both hydrogen isotopes, as fuel for nuclear fusion reactions. Deuterium is stable and can be found in nature. However, tritium decays to ^3_2He, an isotope of helium, through a beta decay:**

$$T \rightarrow {}^3_2He + e^- + \bar{\nu}_e$$

where e^- is electron and $\bar{\nu}_e$ is electron antineutrino. Tritium has a half-life $T_{1/2}$ = 12.3 year meaning that the mass of tritium reduces by half after 12.3 year.

   (a) **If you have one kilogram of tritium, how much is left after 123 years?** (10 %)

   (b) **Please explain why tritium is hardly found in nature?** (5 %)

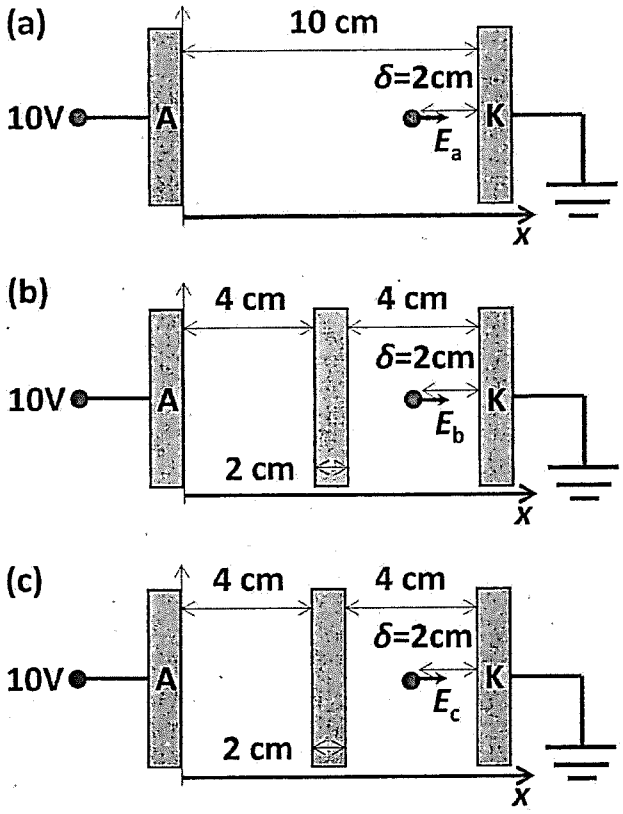
3. (20 % in total) **Shown in the following figures, anodes (A) are connected to 10-V power supplies, and cathodes (K) are grounded. In case (a), nothing is inserted between the anode and the cathode. In case (b), a dielectric material, such as a plastic plate, is inserted between the anode and the cathode. In case (c), a metal plate, such as a copper plate, is inserted between the anode and the cathode.**

   (a) **Please draw the potential and the electric field as a function of x in case (a).** (5 %)

   (b) **Please draw the potential and the electric field as a function of x in case (b).** (5 %)

   (c) **Please draw the potential and the electric field as a function of x in case (c).** (5 %)

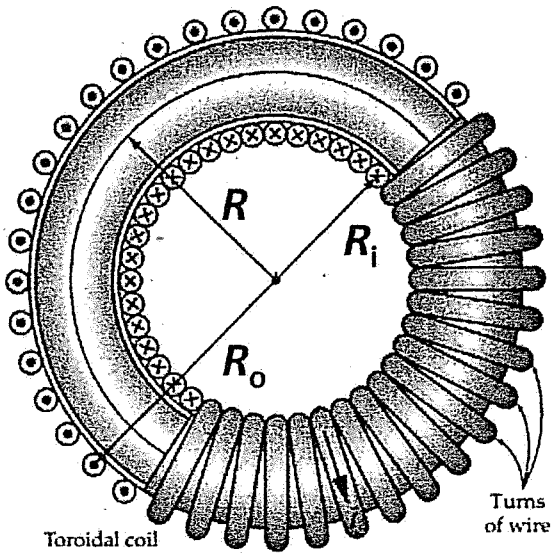
   (d) **At a distance $\delta = 2$ cm away from the cathode (K) as indicated in all figures, please sort the electric field (E_a, E_b, E_c) by magnitude at those points.** (5 %)



4. (15 % in total) Shown in the following figure is a torus with toroidal coils. The inner and outer radius of the toroidal coils are $R_i = 80$ cm and $R_o = 120$ cm, respectively. There are 100 turns of coils.

   (a) What's the magnetic field as a function of current I and radius R? (10 %)

   (b) If one would like to have a magnetic field of 1 T at $R = 100$ cm, what's the required current I? (5 %)



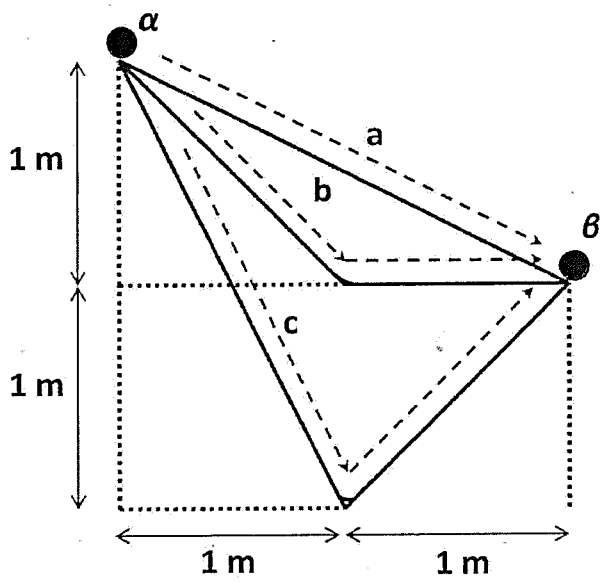
5. (20 % in total) Shown in the following figure, a ball slides down from the location α to the location β through three different paths: a, b, c. In path a, the ball slides along a straight path reaching the location β. In path b, the ball first slides down 1 m in the first 1 m and slides through a flat surface for another 1 m arriving at the location β. In path c, the ball first slides down 2 m in the first 1 m and slides through an uphill going up for 1 m for another 1 m arriving at the location β. Assuming there is no friction. Assuming there is no friction. At any turning point, the ball changes direction while its speed remains unchanged.

   (a) How long does it take for the ball to reach the location β through path a? What's the final speed if the ball reaches the location β through path a?(5 %)

   (b) How long does it take for the ball to reach the location β through path b? What's the final speed if the ball reaches the location β through path b?(5 %)

   (c) How long does it take for the ball to reach the location β through path c? What's the final speed if the ball reaches the location β through path c?(5 %)

   (d) By taking which path does the ball reach the location β fastest?(5 %)



6. (10 % in total) Shown in the following figures are ice cubes in a glass of water. In case (a), there is only one ice cube floating on the surface of the water. In case (b), there are many ice cubes in the water such that at least one of the ice cubes touches the bottom of the glass.

   (a) In case (a), how does the water level H change when the ice cube totally melts? Why? (5 %)

   (b) In case (b), how does the water level H change when all the ice cubes totally melt? Why? (5 %)