107 學年第二學期 普通物理 B 第二次段考試題

[Wolfson Ch. 29, 33-35] 2019/06/18, ***8:20am – 09:50am***

**B**

(i)答案卷第一張正面為封面。第一張正、反兩面**不要寫任何答案。**

(ii)依空格號碼順序在第二張**正面**寫下所有填充題答案，不要寫計算過程。

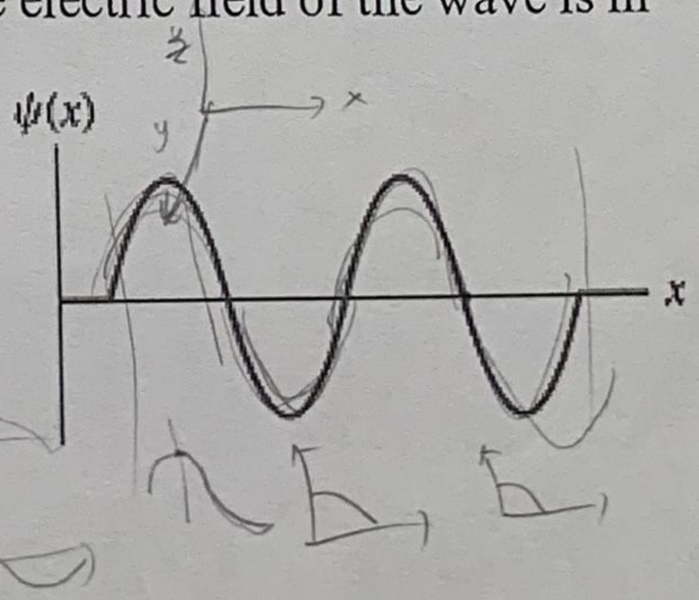
(iii)依計算題之題號順序在第二張**反面**以後寫下演算過程與答案，**每題從新的一頁寫起**。

(iv)根據題目給的參數，**注意答案有效數位。(Please express your answer in significant figures.)**

Constants: $c = 3 \times 10^8 m/s$ ; $\mu_0 = 4\pi \times 10^{-7}$Tm/A; $h = 6.626 \times 10^{-34} Js$; $e = 1.6 \times 10^{-19} C$; $electron\ mass$: $m_{el} = 9.11 \times 10^{-31} kg$; $proton\ mass$: $m_p = 1.67 \times 10^{-27} kg$; $\hbar = 1.055 \times 10^{-34} Js$; $\varepsilon_0 = 8.85 \times 10^{-12} C^2/N \cdot m^2$

**Part I. Filling the blank (5 points per blank)**

- The energy of the ground state in the Bohr model of the hydrogen atom is -13.6 eV. In a transition from the $n = 2$ state to the $n = 4$ state, a photon of energy **[1a]** eV (2.5分) is **[1b]** (emitted/absorbed) (2.5分)
- The maximum electron energy in a photoelectric experiment is 2.50eV. When the wavelength of the illuminating radiation is increased by 60%, the maximum energy drops to 1eV. The original wavelength is **[2]** nm.
- As measured in Earth's rest frame, a spaceship traveling at 0.964*c* takes 11.2 y to travel between planets. How long does the trip take as measured by someone on the spaceship? **[3]** years.
- The magnitude of the Poynting vector of a planar electromagnetic wave has an average value of 0.724 W/m$^2$. What is the maximum value of the magnetic field in the wave? **[4]** nT
- A particle in a 453 m-long linear particle accelerator is moving at 0.875*c*. How long does the particle accelerator appear to the particle? **[5]** m
- An electron inside a hydrogen atom is confined to within a space of 0.110 nm. What is the minimum uncertainty in the electron's velocity? **[6]** m/s.
- The lowest energy level of a certain quantum harmonic oscillator is 5.00 eV. What is the energy of the next higher level? **[7]** eV
- A proton and electron have the same de Brogile wavelength. The speed ratio between electron and proton is **[8]**, assuming v<<c for both.
- A large city consumes electrical energy at the rate of 1GW. If you converted all the rest mass in a 10g raisin (葡萄乾) to electrical energy, it could power up the city for **[9]** hours.
- A laser produces an average power of 10.0W in a 1.55 mm diameter beam. The average intensity is **[10]** MW/$m^2$.The peak electric field of the laser light is **[11]** kV/m.
- The ground-state energy (n=1) for an electron in infinite square well A (Length $L_A$) is equal to the energy of the second excited state (n=3) for an electron in well B ( Length $L_B$). $L_B/L_A$ is **[12]** . Assume one dimensional space.
- If the magnetic field of an electromagnetic wave is in the +*x*-direction and the electric field of the wave is in the +*y*-direction, the wave is traveling in the **[13]** direction.
- The wave function of an electron in a rigid box (infinite well) is shown in the figure. If the electron energy is 98.0 eV, what is the energy of the electron's ground state? **[14]** eV



**Part II Problems (10 points per problem)**

**[1]** Suppose $\psi_1$ *and* $\psi_2$ are solutions of the Schrodinger equation for the same energy E. Show that the linear combination $a\psi_1 + b\psi_2$ is also a solution, where a and b are arbitrary constants.

**[2]** A particle is confined to a one-dimensional box (an infinite well) on the $x$-axis between $x = 0$ and $x = L$. The potential height of the walls of the box is infinite. The normalized wave function of the particle, which is in the ground state, is given by $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{\pi x}{L}\right)$, with $0 \le x \le L$. (a) What is the probability of finding the particle between $x = 0$ and $x = L/3$? (5 points)

$\frac{\sqrt{2L}}{\pi}(1-\cos\frac{\pi}{3})$ $u = \pi x$ $du = \pi dx$

The energy levels of the infinite well is $E = \frac{n^2 h^2}{8mL^2}$. (b) If this box is 2.0 nm wide, the electron makes a transition from the $n = 8$ to the $n = 7$ state, what is the wavelength of the emitted photon? (5 points)

**[3]** Bohr assumed an electron orbited a hydrogen nucleus in circular paths. (3,3,4 points)

(a) What are the angular momentum of the stable orbits in Bohr's model?

(b) Derive the radius of the Bohr's hydrogen atom.

(c) Derive the total energy of the hydrogen atom.

$mvr = n\hbar$

$r = \frac{n\hbar}{mv}$

$E = \frac{ke^2}{2a_0 n^2}$