國　立　清　華　大　學　命　題　紙

96 學年度 工程與系統科學系（所）丙 組、先進光源學程 乙組 及 核子工程與科學研究所 甲組 碩士班入學考試

科目 近代物理 科目代碼 3003、3302、3104 共 1 頁第 1 頁 *請在【答案卷卡】內作答

Useful constants: $c = 3.00\times10^{8}$ m/s, $k_B = 1.38\times10^{-23}$ J/K, $h = 6.63\times10^{-34}$ J·s, $e = 1.60\times10^{-19}$ C, $m_e = 9.11\times10^{-31}$ Kg.

1. (12%) A metal surface is irradiated with monochromatic light of variable wavelength. Above a wavelength of 5400 Å, no photoelectrons are emitted from the surface. With an unknown wavelength a stopping potential of 3 V is necessary to eliminate the photoelectric current. What is the unknown wavelength?

2. (15%) X-ray photons of wavelength 0.712 Å undergo Compton collision in carbon. What is the wavelength change of the line scattered at 90° if the scattering particle is
   (a) an outer electron ?
   (b) the whole carbon atom ?

3. (15%) Find the deBroglie wavelength of the waves associated with an electron that has been accelerated from rest thorough a potential difference of
   (a) 100 V.
   (b) 800,000 V.

4. (13%) Measurements of the mass of a subatomic particle yielded a mass distribution which is centered at 1230 MeV/c^2, and with full width at half maximum about 110 MeV/c^2. Estimate the lifetime of the particle.

5. (15%) Determine the mass of a free particle whose wave function is the plane wave

$$\Psi(x,t) = A\,e^{\,i(2.5\times10^{11}x - 2.1\times10^{13}t)},$$

   where distance (x) is in meters and time (t) in seconds.

6. (15%) One of the excited states of the hydrogen atom has the wavefunction

$$\psi = A\,r\,e^{-r/2a}\cos\theta,$$

   where a is the Bohr radius.
   (a) Find the normalization constant A.
   (b) Find the most probable value of r.

7. (15%) (a) Write all possible total angular momentum states (j, m_j) for a 3d electron in a hydrogen.
   (b) Assume that the spin-orbit interaction is not overwhelmed by an external magnetic field, what is the minimum angle that the total angular momentum vector $\vec{J}$ may make with the z-axis for the 3d electron.
   (c) What are possible angles between vectors $\vec{L}$ and $\vec{S}$ for the 3d electron due to the spin-orbit interaction.