國　立　清　華　大　學　命　題　紙

97 學年度 工程與系統科學系丙 組、先進光源科技學位學程乙組 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、3202、3103 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, $\mu_B = 9.274\times10^{-24}$ J/T, $R = 1.097\times10^{7}$ m^{-1}.

1. (20%) (a) Two spaceships A and B are moving in opposite directions. An observer on Earth measures the speed of A to be $0.80\,c$ and the speed of B to be $0.90\,c$. Find the velocity of B with respect to A.
   (b) A space ship moves away from earth at a speed of 0.5 c. On the earth, light pulses are sent toward the spaceship at an interval of one year, what is the time interval of the light pulses when they are received by the people on the space ship?
   (c) A particle is observed with momentum 500 MeV/c and total energy 1746 MeV. What is its speed (in MeV/c^2)? What is its mass (in Kg)?

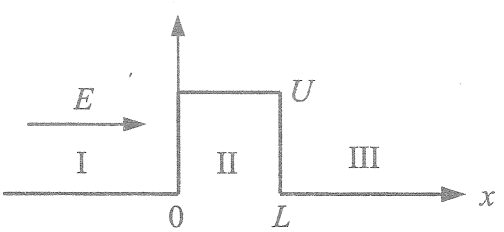
2. (10%) Find the kinetic energy of an electron whose deBroglie wavelength is the same as that of a 10 keV X-ray.

3. (10%) If the maximum kinetic energy given to the electrons in a Compton scattering experiment is 10 keV, what is the wavelength of the incident X-rays?

4. (15%) (a) In the hydrogen spectrum, the H_α line is the first line of the Balmer series (from $n_i = 3$ to $n_f = 2$). Calculate the wavelength of the H_α line.
   (b) Radiation from a helium ion (He^+) is nearly equal in wavelength (to a few Å) to the H_α line. Between what states (values of n_i and n_f) does the transition in He^+ occur?
   (c) Is the wavelength of that radiation from He^+ in (b) greater or smaller than that of the H_α line? Compute the wavelength difference using the reduced mass.

5. (15%) In the technique known as electron spin resonance (ESR), a sample containing unpaired electrons is placed in a magnetic field. Consider the simplest situation, that in which there is only one electron and therefore only two possible energy states, corresponding to $m_s = \pm\frac{1}{2}$. In ESR, the electron's spin magnetic moment is "flipped" from a lower energy state to a higher energy state by the absorption of a photon. What is the photon frequency required to excite an ESR transition in a magnetic field of 0.2 T?

6. (15%) A particle (mass m) of energy $E<U$ approaches a rectangular potential barrier from the left (see figure below).
   (a) Write down solutions to the time-independent Schrodinger equations for regions I, II, and III respectively.
   (b) Write down the boundary conditions to join the solutions.
   (c) Define the transmission coefficient T.
   (d) A useful approximate formula is $T \approx e^{-2k_2L}$. What is k_2? Under what condition is this formula valid?



7. (15%) (a) Write down Moseley's law for K_α X-rays and explain it.
   (b) Estimate the wavelength of the K_α line of silver ($Z = 47$).