國立清華大學 100 學年度碩士班入學考試試題

系所班組別：聯合招生(工科丙組、先進光源工科組)

考試科目（代碼）：近代物理(9802)

Useful constants: $c = 3.00 \times 10^8$ m/s, $k_B = 1.38 \times 10^{-23}$ J/K, $h = 6.63 \times 10^{-34}$ J·s, $e = 1.60 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ Kg, $\mu_B = 9.274 \times 10^{-24}$ J/T, $R = 1.097 \times 10^7$ m^{-1}, Avogadro constant $N_A = 6.022 \times 10^{23}$ mol^{-1}, mass of neutron: 1.6749×10^{-27} kg

1. The nucleus of a beryllium atom has a mass of 8.003111 u, where u is an atomic mass unit: 1.66×10^{-27} kg. This nucleus is known to spontaneously fission (break up) into two identical pieces, each of mass 4.001506 u. Assuming the beryllium nucleus initially at rest, at what speed will its fission fragments move (in units of light speed), and how much energy is released (in units of keV)? (18 points)

2. A series of hydrogen spectral lines (emission spectrum): 656.3 nm, 486.1 nm, 434.1 nm, 410.2 nm, etc. Please find a formula that predicts the wavelengths of these lines. What is the meaning of this formula? Also, find the converging line wavelength of this series. (16 points)

3. A certain crystal has a planar spacing of 0.25 nm. What minimum energies (in units of eV) are necessary to observe up to three interference maximum for (a) electrons and (b) neutrons? (16 points)

4. (a) An ensemble of nuclei is in alpha decay. Its decay constant is 1.29×10^{-18} alphas per second, what is the half life of these nuclei? _____ (4 points)

   (b) According to the Moseley's law, what is the relation between the energy of K_α with respect to atomic number Z? _____(4 points)

   (c) The orbital moment, μ, of an atomic electron is proportional to its orbital angular momentum L. What is the "name" of the constant of proportionality between μ and L? _____ (in English only) (4 points)

5. (a) Atomic moments are measured in Bohr magnetons, μ_B. What is the relationship among μ_B, m_e and e (where m_e is mass of electron, e the charge)? _____ (4 points)

   (b) Please write down an one dimension time dependent Schrödinger's equation:_____ (4 points).

   (c) In the emission spectra of an atomic hydrogen, why is the 3p to 2p transition forbidden? _____(4 points)

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6. (a) Please write down the electron configuration of a Mn atom in ground state, starting from 1s orbit. (The atomic number of Mn is 25) _____(4 points).

   (b) An object with mass 1.0 g is whirled in a horizontal circle of diameter 1.00 m with a period of revolution equal to 1.00 s, what value of orbit quantum number l describes this motion? (6 points).

7. In a STM (scanning tunnel microscopy) experiment, we found the tunneling current density is proportional to exp(-2L/δ), where the L is the distance between the material surface and the tips; and δ is the characteristic scale of length for tunneling which is set by the working function (U-E). Note that the electron in the surface or tip has potential energy –U compared with one in vacuum, and the kinetic energy of electron in the surface is E. If the work function (U-E)=3.9 eV, what is the characteristic scale of length δ =_____? (4 points). Then, if I decrease the distance between the tip and material surface by 1 pm, how many times will the tunnel current increased? _____ (4 points).

8. A nuclear potential that binds nucleons in a nucleus is often by a square well. Imagining a neutron confined in a infinite square well of length 10^{-5} nm, calculate the wavelength and energy associated with the neutron that is emitted when the neutron undergoes a transition from the second excited state (n=3) to the first excited state (n=2). Answer: _____ (8 points).