國立清華大學 103 學年度碩士班考試入學試題

系所班組別：0598 聯合招生

考試科目（代碼）：9802 近代物理

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, Coulomb constant $k = 8.988\times10^{9}$ N·m^2/C^2.

1. (10%) A high speed K^0 meson is traveling at a speed of 0.9 c when it decays into a π^+ and a π^- meson. What are the greatest and the least speeds that the π^+ and π^- mesons may have. (the rest mass energy of K^0 is 498 MeV, and the rest mass energy of π^+ or π^- meson is 140 MeV).
2. (6%) What is the shortest wavelength of the X-rays generated by 80 KeV electrons hitting on a copper target of an X-ray generator.
3. (6%) For a Rutherford scattering experiment using a foil with atomic number 29, the counting rate (number of the scattered alpha particles per miniute) for a give detector position (scattering angle) is 120 counts per minute. What would be the counting rate if the atomic number is 79 ?
4. (14%) A beam of thermal neutrons with kinetic energy 0.025 eV scatters from a powder crystal with interatomic spacing 0.45 nm. What is the neutron wavelength? What is the angle between the incident beam and the scattered beam of the first-order Bragg peak? (neutron mass: $m_n = 1.675\times10^{-27}$ Kg; 1 nm $= 10^{-9}$ m)
5. (14%) Derive the equation for the radius of the electron orbit and the energy state of a hydrogen atom according to the theory of Bohr's quantum model of the atom.
6. In a free space, I have two particles interacting between each other. The mass of these two particles are 2 m_0 and 10 m_0, respectively; m_0 is a unit at rest mass. What is the reduced mass of the lighter particle? _____(5%)
7. Which kind of potential well giving the separation between energy levels as $h\nu$? _____(5%) (note: $h\nu = \hbar\omega$)
8. What is the expectation value <x> of the position of a particle in a box L wide? _____(10%)

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9. An eigenfunction of the operator $\frac{d^2}{dx^2}$ is $p = e^{2x}$. Find the corresponding eigenvalue. _____(10%)

10. How much more likely is a 1s electron in a hydrogen atom to be at the distance r_0 from the nucleus than at the distance $r_0/2$? _____(10%).

    Assume that the radial wavefunction R for hydrogen-like atoms for $n = 1$ is $2(Z/a_0)^{\frac{3}{2}} e^{-Zr/a_0}$; a_0 is the Bohr radius.

11. Answer the following questions:

    (1) Please write down the electron configuration of a nitrogen (Z=7) atom. (2%)

    (2) Please write down the electron configuration of a Co (Z=27) atom. (2%)

    (3) Please write down the sequence of atomic volume of the following atoms (from the smaller to larger): Ne, Na, Rb, Cs. (2%)

    (4) Please write down the sequence of ionization energy of electrons of the following atoms (from the smaller to larger): Ne, Na, Xe, Cs. (2%)

    (5) The K_α X-ray is emitted in the transition from excited shell to ground shell. Please tell me which excited shell to which ground shell. Write down the names of the shells. (2%)