九十二學年度＿＿＿生命科學院＿＿＿系（所）＿＿＿丙＿＿＿組碩士班研究生招生考試

科目＿＿近代物理＿＿科號＿1002＿共＿3＿頁第＿1＿頁 *請在試卷【答案卷】內作答

Plank's constant $h = 6.626 \times 10^{-34}$ joule-sec

Coulomb's law constant $1/4\pi\varepsilon_0 = 8.998 \times 10^{9}$ nt-m^2/coul^2

Bohr magneton $\mu_b = e\hbar/2m_e = 9.27 \times 10^{-24}$ joule/T

Bohr radius $a_0 = 4\pi\varepsilon_0 \hbar^2 / m_e e^2 = 5.29 \times 10^{-11}$ m

Bohr energy $E_1 = -m_e e^4 / (4\pi\varepsilon_0)^2 (2\hbar^2) = 13.6$ eV

Electron Compton wavelength $\lambda_c = h / m_e c = 2.43 \times 10^{-12}$ m

Rydberg constant $R_\infty = 109737$ cm^{-1}

Boltzmann's constant $k = 1.38 \times 10^{-23}$ joule/°k

1 eV $= 1.602 \times 10^{-19}$ joule

$m_e = 0.511$ MeV/c^2 $\quad\quad$ $hc = 1.240 \times 10^{3}$ eV nm

Part I (50%)

Note: There are 10 blanks from A to J in this part. Each gets 5 points (5%). Please list the answers of each blank on the first page of your answer sheet.

1. A pion with a rest energy of 135MeV, moves through the laboratory at v=0.98c and decays into two gamma rays of equal energies making equal angle θ with the direction of motion. Find the angle θ __(A)__ and the energy __(B)__ of each gamma ray.

2. X-ray of wavelength 0.24nm are Compton-scattered, and the scattered beam is observed at an angle of 60.0° relative to the incident beam. Find the wavelength (C)__ of the scattered x-rays, and the kinetic energy __(D)__ of the scattered electrons.

3. A charged particle with charge e, rest mass m_0 is applied by an accelerating potential V, and moves at relativistic speeds, what is its de Broglie wavelength (E)__?

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4. A particle's motion is limited to x-axis, it has wave function ϕ=ax between x=0 and x=1; ϕ=0 elsewhere. What is the probability __(F)__ that the particle can be found between x=0.4 and 0.5? and what is the expectation value <x> __(G)__ of the particle's position?

5. A collection of hydrogen atoms is placed in a magnetic field of 3.50 T. Ignoring the effects of electron spin. Find the wavelengths __(H)__ of the three normal Zeeman components of the 3d to 2p transition.

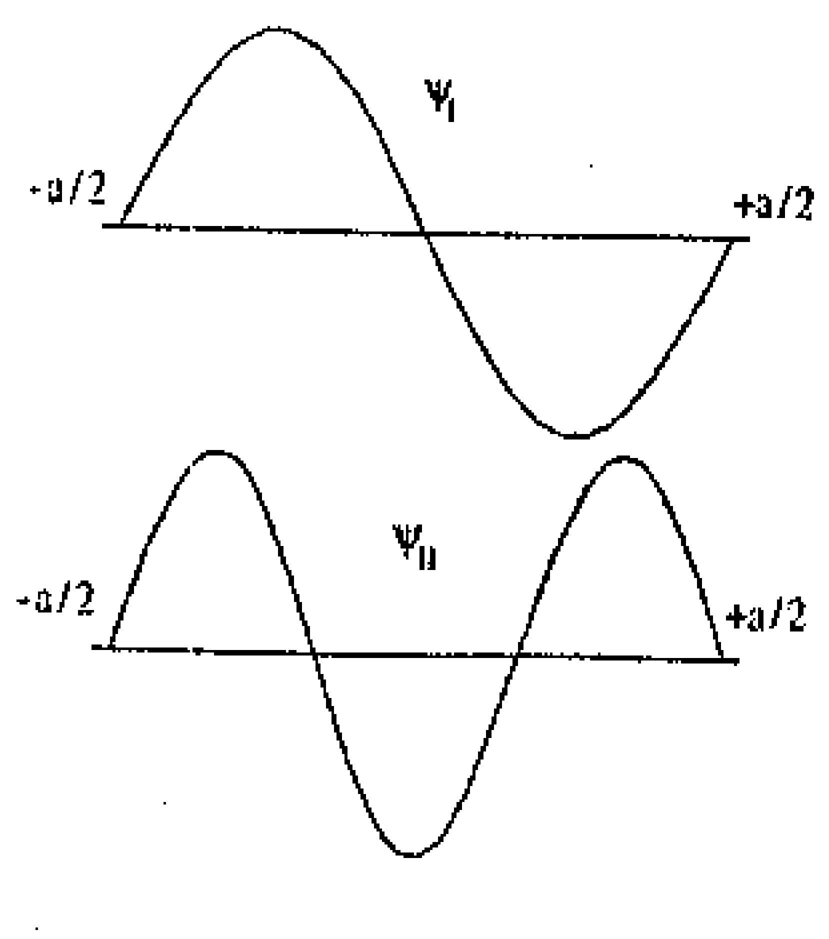
6. The electronic configuration of carbon atom (Z=6) is $1s^2 2s^2 2p^2$. Find the total orbital quantum number __(I)__ and spin quantum __(J)__ on its ground state.

Part II (50%)

Note: There are four problems in this part. Please write down the answers start from the second page of your answer sheet.

1. (12%) A muonic atom contains a nucleus of charge Ze and a negative muon, μ-, moving about it. The μ- is an elementary particle with charge –e and a mass that is 207 times as large as an electron mass. Such an atom is formed when a proton, or some other nucleus, captures a μ-.
   (a) Calculate the radius of first Bohr orbit of a muonic atom with Z=1.
   (b) Calculate the binding energy of a muonic atom with Z=1.
   (c) What is the wavelength of the first line in the Lyman series of such an atom?

2. (10%) Two possible eigenfunctions for a particle moving freely in a region of length a, but strictly confined to that region, are shown in Figure A. When the particle is in the state corresponding to the eignfunction ψ_I, its total energy is 4eV.
   (a) What is its total energy in the state corresponding to ψ_{II}?
   (b) What is the lowest possible total energy for the particle in this system?



3. (14%) In its ground stat, the size of the hydrogen atom can be taken to be the radius of the n=1 shell for Z=1, which is essentially $a_0 = 4\pi\varepsilon_0\hbar / \mu e^2 \approx 0.5\,\text{Å}$. Show that this fundamental atomic dimension can be obtained directly from consideration of the uncertainty principle.

4. (14%) A beam of hydrogen atoms, emitted from an oven running at temperature T=400°K, is sent through a Stern-Gerlach magnet of length X= 1m. The atoms experience a magnetic field with a gradient of 10 tesla/m. Calculate the transverse deflection of a typical atom in each component of the beam, due to the force exerted on its spin magnetic dipole moment, at the point where the beam leaves the magnet.