1. (6 %) A light source with wavelength λ illuminates a metal and ejects photoelectron of a maximum kinetic energy of 1 eV. Another light source with wavelength λ/2 ejects photoelectron of a maximum kinetic energy of 4 eV. What is the work function (in eV) of the metal?

2. (4 %) (a) Show that the energy-momentum relationship given by $E^2=p^2c^2+(mc^2)^2$ follows from the expression $E=\gamma mc^2$ and $p=\gamma m v$, where γ is $\frac{1}{\sqrt{1-v^2/c^2}}$

   (4 %) (b) The total energy of a proton is three times of its rest energy. Find the proton's rest energy (in eV) and its moving speed.

   (4 %) (c) Determine the kinetic energy of the proton in electron volts.

   (6 %) (d) What is the proton's momentum (in eV/c)?

   [Mass of proton $m_p= 1.67 \times 10^{-27}$ kg, 1 eV = 1.6×10^{-19} J, $\sqrt{2}=1.414$]

3. (6 %) Calculate the de Broglie wavelength (in meter) of a 74-kg person who is running at a speed of 5.0 m/s. [$h=6.63 \times 10^{-34}$ J·s]

4. (4 %) (a) Use Stefan's Law to calculate the total power radiation per unit area by a filament at a temperature of 3000 K assuming the filament is an ideal radiator. [$\sigma = 5.7 \times 10^{-8}$ W/m^{2}K^4]

   (4 %) (b) Assume that the sum radiates as a black body with a surface temperature of 5800 K. Use Wien's displacement law to show the peak (in nm) of the solar spectrum. [Wien's displacement constant = 2.898×10^{-3} mK]

   (4 %) (c) What is the average energy $\overline{E}$ (in KT) of an oscillator that has a frequency hν=KT according to Planck's calculation? [e=2.718]

5. (4 %) (a) What is the electronic configuration (ground state) of element Al (aluminum) whose atomic number Z=13.

   (4 %) (b) What are the quantum numbers (n, l, m, s) for the electron at the out most orbital?

（下一頁還有試題）

6. A free particle of mass m with wave number k_1 is traveling to the right. At x = 0, the potential jumps from zero to V_0 and remains at this value for positive x.
   (4 %) (a) If the total energy is $E = 2V_0$, what is the wave number k_2 in the region $x > 0$? Express your answer in terms of k_1 and V_0.
   (8 %) (b) Calculate the reflection coefficient R and the transmission coefficient T.
   (4 %) (c) What is the probability current carried by this particle?

7. (8 %) What are the possible values of the total angular momentum of an electron in a *d* state (the $\ell = 2$ state)? What are the angles between the spin and the orbital angular momentum? Please also compute the magnitude of the spin and orbital angular momenta.
   (8 %) In a carbon atom, only the two 2p electrons contribute to its angular momentum. The ground state of this atom is $^3P_0$, and the first four excited states, in order of increasing energy, are $^3P_1$, $^3P_2$, $^1D_2$, $^1S_0$. (a) Give the **L**, **S**, **J** values for each of these five states. (b) Why do you think the $^3P_0$ state is the ground state?

8. (3 %) (a) If $\psi_\alpha(1)$ represents particle 1 in the α state, use this representation to write normalized wave function for a system of three particles, when these three particles are Fermions.
   (3 %) (b) What is Fermi-Dirac distribution?
   (6 %) (c) A metal of volume V contains N electrons. The number of quantum states in an energy interval E to E+dE is given by
   $g(E)\,dE = \dfrac{8\sqrt{2}\,\pi V m^{3/2}}{h^3}\sqrt{E}\,dE$. Please derive the Fermi energy.
   (6 %) (d) Following (b) and (c), please derive the average energy of an electron at T = 0 K.