

國立中央大學九十學年度碩士班研究生入學試題卷

所別: 電機工程學系 乙組 科目: 近代物理 共 一 頁 第 一 頁

1. A particle of charge q and mass m is accelerated from rest through a small potential V . Find its de Broglie wavelength. (10 points)

2. In quantum mechanics, matter waves (or de Broglie waves) are represented by a wavefunction $\Psi(x,t)$. The wave function must satisfy the Schrödinger equation. For a particle confined to a one-dimensional box (infinite square well) of length L , the particle energies are quantized. Obtain the quantized energies and the wavefunctions. (20 points)

3. Consider a particle incident on a square barrier. The energy E of the particle is less than the barrier height U (barrier width L). Obtain the transmission coefficient for the case.

$$T(E) = \left\{ 1 + \frac{1}{4} \left[\frac{U^2}{E(U-E)} \right] \sinh^2 \alpha L \right\}^{-1} \quad \text{with} \quad \alpha = \frac{\sqrt{2m(U-E)}}{\hbar}$$

Is the above equation also good for energy exceeding the barrier height ($E > U$)? Why? (20 points)

4. (a) What kind of particles follows Fermi-Dirac distribution? (b) Draw the schematic diagrams of Fermi-Dirac distribution function at absolute zero and room temperature, respectively. (c) Indicate the position of Fermi energy and explain its physical meaning. (15 points)

5. Derive the density of states for electrons in a metal. (15 points)

6. The normalized ground state wavefunction for the electron in the hydrogen atom is $\Psi(r,\theta,\phi) = (1/\pi^{1/2})(1/a)^{3/2} e^{-r/a}$, where r is the radial coordinate of the electron and a is the Bohr radius. Calculate the average potential and kinetic energies for the electron in the ground state of hydrogen. (20 points)