國立中央大學101學年度碩士班考試入學試題卷

所別：電機工程學系碩士班 固態組(一般生)　科目：近代物理　共 1 頁 第 1 頁

本科考試禁用計算器

*請在試卷答案卷（卡）內作答

1. To "observe" small objects, one measures the diffraction of particles whose de Broglie wavelength is approximately equal to the object's size. Find the kinetic energy (in electron volts) required for electrons to resolve (a) atomic features of size 0.10 nm, (*5 pts.*) and (b) give an example on the tool for the observation. (*5 pts.*)
2. What are the deficiencies of Bohr's model of atom and how does quantum mechanics fix these deficiencies? (*10 pts.*)
3. Solve the Schrodinger equation for a particle in an infinite square well, draw the wave functions for the first three quantized states, and discuss how the energies of these states are related. *(15 pts)*
4. Consider a particle in an infinite square well described initially by a wave that is a superposition of the ground and first excited states of the well:

   $\Psi(x,0) = C[\psi_1(x) + \psi_2(x)]$

   (a) Derive the value of C by normalizing this wave, assuming ψ_1 and ψ_2 are themselves normalized. (*5 pts.*)

   (b) Find $\psi(x,t)$ at any later time *t*. (*5 pts.*)

   (c) Show that the superposition is not a stationary state, but that the average energy in this state is the arithmetic mean $(E_1+E_2)/2$ of the ground- and first excited-state energies E_1 and E_2. (*5 pts.*)
5. An electron and a proton of identical energy encounter the same potential barrier. For which is the probability of transmission greater, and why? *(5 pts.)*
6. Sodium is a monovalent metal having a density of 0.971 g/cm^3, an atomic weight of 23.0 g/mol, and a resistivity of 4.20 μΩ · cm at 300 K. Use this information to calculate (a) the free electron density; *(5 pts)* (b) the Fermi energy, E_F, at 0 K; *(5 pts)* (c) the Fermi velocity, υ_F; *(5 pts)*
7. Explain how the energy bands of metal, semiconductors, and insulators account for the facts that (a) Metals are opaque to visible light. (b) Semiconductors, such as Si and GaAs, are opaque to visible light but transparent to infrared. (c) Insulators, such as diamond and quartz, are transparent to visible light. *(15 pts)*
8. Discuss the basic assumptions and draw the curves of Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics. How do they differ, and what are the similarities? *(15 pts)*

Constants and formulas:

$h = 6.626 \times 10^{-34}$ J-s

$m_e = 9.11 \times 10^{-31}$ kg

$c = 3 \times 10^8$ m/s

$R = 1.0974 \times 10^7$ m^{-1}

$$J = ne\upsilon_d = \frac{ne^2\tau E}{m_e}, \sigma = \frac{ne^2\tau}{m_e}, E_F(0) = \frac{h^2}{2m_e}\left(\frac{3N}{8\pi V}\right)^{2/3}$$