國立成功大學 108 學年度碩士班招生考試試題

系　　所：光電科學與工程學系

考試科目：近代物理

考試日期：0224，節次：1

※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Useful Physical Constants:

Speed of light	$c = 2.998 \times 10^{8}$ m/s
Electronic charge	$e = 1.602 \times 10^{-19}$ C
Boltzmann constant	$k = 1.381 \times 10^{-23}$ J/K $= 8.617 \times 10^{-5}$ eV/K
Planck's constant	$h = 6.626 \times 10^{-34}$ J·s $= 4.136 \times 10^{-15}$ eV·s
Avogadro's constant	$N_A = 6.022 \times 10^{23}$ mole^{-1}
Electron mass	$m_e = 5.49 \times 10^{-4}$ u $= 0.511$ MeV/c^2
Proton mass	$m_p = 1.007276$ u $= 938.3$ MeV/c^2
Neutron mass	$m_n = 1.008665$ u $= 939.6$ MeV/c^2
Bohr radius	$a_0 = 0.0529$ nm
Hydrogen ionization energy	13.6 eV
Thermal energy	$kT = 0.02525$ eV $\cong \frac{1}{40}$ eV ($T = 293$ K)
$hc = 1240$ eV·nm (MeV·fm)	$\hbar c = 197$ eV·nm (MeV·fm)
$\frac{e^2}{4\pi\varepsilon_0} = 1.440$ eV·nm (MeV·fm)	1 u $= 931.5$ MeV/c^2
	1 eV $= 1.602 \times 10^{-19}$ J

1. (a) Describe the Einstein's postulates in the theory of relativity.
   (b) A particle has the mass m_0 and moves with the velocity v. Write the total relativistic energy of the particle.
   (c) In the laboratory frame, particle 1 is at rest with total relativistic energy E_1, and particle 2 is moving to the right with total relativistic energy E_2 and momentum p_2. Show that the frame in which the center of the relativistic masses of the system is moving to the right with velocity

$$u = c\frac{cp_2}{E_1+E_2}$$

   relative to the laboratory frame. (Particles 1 and 2 have the same mass m_0.) (12%)
2. (a) Describe the Plank's postulate for the total energy.
   (b) Based on the Plank's theory and the Boltzmann probability distribution $P(\varepsilon) = Ae^{-\varepsilon/kT}$, please drive the average energy $\bar{\varepsilon}$ in thermal equilibrium. Here, A is constant and ε is energy. Moreover, the symbols of ν can be used to represent the frequency.
   (c) Schematically draw the figure of the Plank's theoretical spectrum, and label the wavelength regions which satisfy the Wien's law and Rayleigh-Jeans theory. (13%)
3. Please illustrate the following terminologies: (9%)
   (a) de Broglie's postulate
   (b) the uncertainty principle
   (c) the Compton effect
4. (a) Write the Schrödinger equation and the time independent Schrödinger equation.
   (b) Considering an one-dimension system, a barrier potential is

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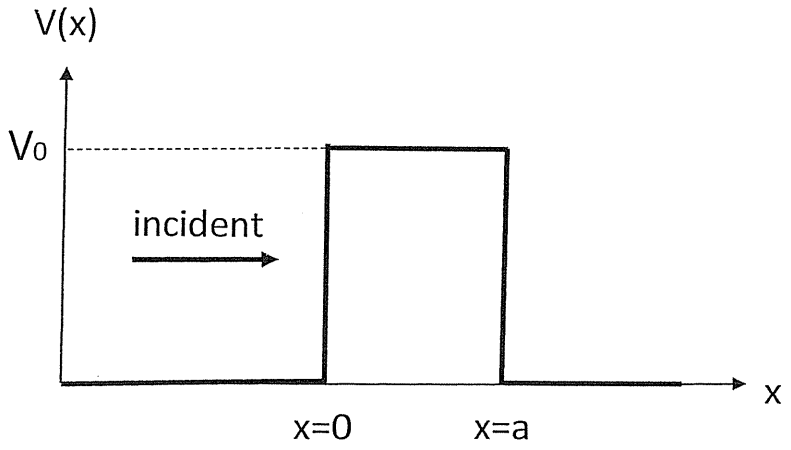
$$V(x) = \begin{cases} 0, x < 0 \\ V_0, 0 < x < a. \\ 0, x > a \end{cases}$$



A particle with total energy E ($E<V_0$) is incident upon the barrier in the direction of increasing x. Please find the eigenfunction which is the solution to the time independent Schrödinger equation. Moreover, draw the real part of a eigenfunction as a function of x, and explain the difference between the classic and quantum mechanics. (16%)

5. Write the ground-state electron configuration of (a) carbon, (b) argon. (10%)
6. The Fermi energy for gold is 5.51 eV at T=293K. (a) Find the average energy of a conduction electron at that temperature. (b) Compute the temperature at which the average kinetic energy of an ideal gas molecule would equal the average energy you found in (a). (10%)
7. LEDs of varying colors can be made by mixing GaN (E_g=3.4 eV) and InN (E_g=0.7 eV) in different proportions. Calculate the relative amounts of GaN and InN needed to produce an LED that emits (a) green light (550 nm) and (b) violet light (400 nm) (10%)
8. Assuming the energy gap in intrinsic silicon is 1.1 eV and that the Fermi energy lies at the middle of the gap, calculate the occupation probability at 293K of (a) a state at the bottom of the conduction band and (b) a state at the top of the valence band. (10%)
9. A laser emits $5.50*10^{18}$ photons per second, using a transition from an excited state with energy 1.15 eV to a ground state with energy 0 eV. (a) What is the laser's power output? (b) What is the wavelength? (10%)