國立成功大學 104 學年度碩士班招生考試試題

系所組別：光電科學與工程學系甲組

考試科目：近代物理

考試日期：0212，節次：1

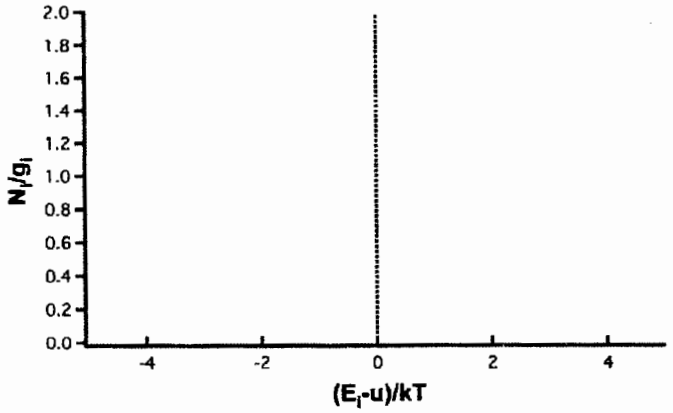
※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

A lot of useful physical constants are shown as below:

Speed of light in vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
Planck constant divided by 2π	$\hbar = 1.055 \times 10^{-34}\ \mathrm{J\,s}$
Electronic charge (absolute value)	$q_e = 1.602 \times 10^{-19}\ \mathrm{C}$
Fine structure constant	$\alpha = q_e^2/(4\pi\varepsilon_0\hbar c) = e^2/(\hbar c) = 1/137$
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg} = 0.511\ \mathrm{MeV}\,c^{-2}$
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg} = 938\ \mathrm{MeV}\,c^{-2}$
Bohr magneton	$\mu_B = q_e\hbar/(2m_e) = 5.79 \times 10^{-5}\ \mathrm{eV\,T^{-1}}$
Nuclear magneton	$\mu_N = q_e\hbar/(2m_p) = 3.15 \times 10^{-8}\ \mathrm{eV\,T^{-1}}$
Bohr radius	$a_0 = \hbar^2/(m_e e^2) = 0.529 \times 10^{-8}\ \mathrm{m}$
Rydberg constant	$R_\infty = m_e e^4/(2\hbar^2) = 13.61\ \mathrm{eV}$
Boltzmann constant	$k_B = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Electron volt and temperature	$1\ \mathrm{eV} = 1.602 \times 10^{-19}\ \mathrm{J} = k_B \times 11\,600\ \mathrm{K}$
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$

1. (a) Please write down the ground state electron configuration of element Silicon. (3%) (b) What are the numbers of electrons in a filled shell with principle quantum number of n ? (3%) (c) Please list all the available quantum numbers (n, l, m_l, m_s) of the 3*p* subshell level. (4%)

2. (a) Please draw the distribution probability function for the three statistics (Maxwell Boltzmann, Bose-Einstein, and Femi-Dirac) on the plot below. (6%)



On the plot, N_i is number of particles on the *i-th* energy level, g_i is the quantum states of the *i-th* energy level, E_i is the *i-th* energy level, and u is chemical potential

(b) For a system at equilibrium having 6 particles with fixed energy ($U=E_0+3E_1+2E_2$) and quantum energy states shown in the figure below, please calculate the possible microstates configurations for the occupation by Bose-Einstein and Fermi-Dirac Statistics. (4%)

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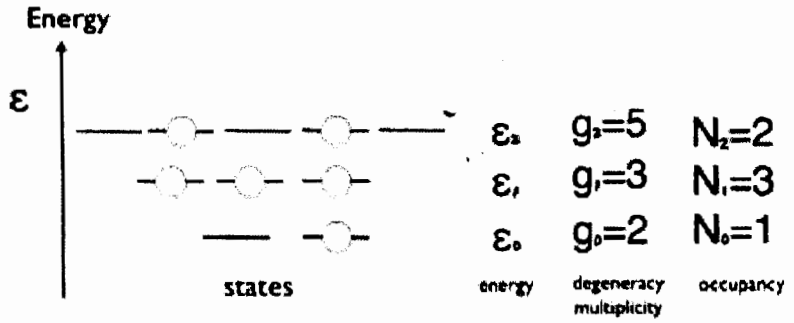
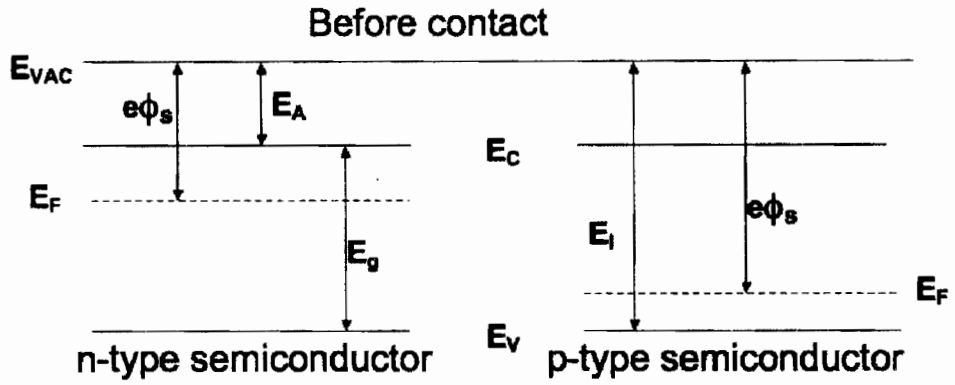


3. (a) Please draw the energy band diagram for a homogeneous pn junction (like figure below) after contact in the following two conditions: (a1) dark at equilibrium. (a2) under illumination at open circuit. (7%) (b) Plot the current-voltage characteristic curve for a homogeneous pn junction. (3%)



Φ_s: Work function; E_A: Electron affinity; E_i: Ionization energy and E_g: Energy band gap

4. Please explain the terminologies below: (20%)
   (a) Zeeman Effect
   (b) Selection Rule (For quantum transition)
   (c) Characteristic X-ray
   (d) Wien's displacement Law
   (e) Fermi energy

5. A particle of mass m under the influence of a restoring force proportional to the displacement from the rest position and producing vibrations of a certain eigenfrequency along one dimension. (a) Write down time-dependent Schrödinger equation for this particle. (b) What are the energy states and zero-point energy for this particle? (10%)

6. In a Compton scattering experiment, the incident X-rays have a wavelength of 0.2685 nm, and the scattered X-rays have a wavelength of 0.2703 nm. Please calculate the angle between incident and scattered directions of X-rays? (10%)

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7. An electron is accelerated through a potential difference $\Delta V = 10^8$ V, what is its de Broglie wavelength? (10%)
8. Please illustrate the following terminologies:
   (a) Population inversion (4%)
   (b) Wave-particle duality (3%)
   (c) Photoelectric effect (3%)
9. An electron moves in one dimension and is subject to forces corresponding to a potential energy:

$$V(x) = v\left[-\delta(x) + \delta(x - L)\right].$$

What are the conditions for the existence of a bound state? (10%)