1. Consider an abrupt p-n junction with a donor concentration of N_D and an acceptor concentration of N_A being doped in its n-side and p-side, respectively.
   (a) Draw the energy band diagram of the junction at thermal equilibrium. (5%)
   (b) Show the *built-in potential* (V_{bi}) in terms of N_D , N_A and n_i , under thermal equilibrium at a temperature of T ,where n_i is the intrinsic carrier concentration of the materials. (5%)
   (c) For a Si p-n junction with $N_A = 10^{18}\ cm^{-3}$ and $N_D = 10^{15}\ cm^{-3}$ at 300 K, find its V_{bi} . (5%)
   (d) Show the current (I)-voltage (V) characteristics of a p-n junction when it is forward-biased by an applied voltage " V " . (5%)
   (e) Describe the origin that making the value of *ideality factor* (η) of a real p-n junction falling between 1and 2. (5%)

2. The p-n junction photonic devices including light emitting diodes (LEDs), laser diodes (LDs), photodiodes (PDs), and solar cells have been applied in the solid state display, optical fiber communication and solar energy related facilities.
   (a) Show the relationship of wavelength (λ) and photon energy (E) of the light. (5%)
   (b) Describe the difference in the radiative emission processes of an LED and an LD. (5%)
   (c) Show the current (I)-voltage (V) characteristics of a p-n junction solar cell and find its open circuit voltage (V_{oc}). (5%)
   (d) Show the threshold condition of the cavity of an LD in terms of its optical gain (g), absorption coefficient (α), length of the cavity (L), and the reflectance of the ends of the cavity (R). (5%)
   (e) Describe the mechanism of the generation of photocurrent in an *avalanche* photodiode. (5%)

3. Please describe the following items :
   (a) Fermi-Dirac distribution function. (5%)
   (b) Hall effect measurement. (5%)
   (c) Short-Channel effect in the MOSFET. (5%)
   (d) Early effect in the BJT. (5%)
   (e) Einstein relation. (5%)

4. (a) Please explain detailedly how to obtain a Schottky contact for the metal /P-type Si. junction (12%)
   (b) Please plot the relation of electron mobility in Si versus temperature and explain why. (13%)