1. A PN junction LED has cross-sectional areas of $A=10^{-3}$ cm^2. The reverse-saturation current densities at T=300 K is 10^{-12} A/cm^2. A forward-bias current of 5 mA is required in this diode. The bandgap energy is 3 eV.
   (a) Calculate the emission wavelength of this LED. (10 %)
   (b) Determine the forward-bias voltage required across the PN junction diode. (10%)
   (c) What is the external quantum efficiency and internal quantum efficiency of LED? (10%)

2. Please sketch the ideal energy-band diagrams for an ideal metal-to-n-type semiconductor junction (a) before and after **"ohmic"** contact, (b) before and after "Schottky" contact. Please label the following terms: E_c, E_v, E_F, ϕ_m (work function of metal), ϕ_s (work function of semiconductor), ϕ_{Bn} (barrier height), χ (electron affinity of semiconductor), V_{Bi} (bulid-in potential)...... (20%)

3. For measuring the following parameters of semiconductor including: (a)resistivity, (b)carrier type, (c)majority carrier concentration, (d)majority carrier mobility, and (e)photoconductivity, what kinds of experiments you will establish and detailedly explain how they work. (35%)

4. Please explain the following items:
   (1) Effective mass.　(5%)
   (2) Gunn diode.　(5%)
   (3) The Ebers-Moll model for p-n-p transistor.　(5%)