1. (25%) An abrupt Si p-n junction has an acceptor concentration $N_a = 10^{17} cm^{-3}$ on

   the p-side and a donor concentration $N_d = 10^{16} cm^{-3}$ on the n-side at 300K. (a)

   Please find the contact potential, and (b) draw an equilibrium band diagram which

   shows the exact position of Fermi level in each side. (Give the Boltzmann's

   constant $k = 1.38 \times 10^{-23} J/K$, band gap of Si $E_g = 1.2eV$, and the intrinsic

   carrier concentration of Si $n_i = 1.5 \times 10^{10} cm^{-3}$.)

2. (25%) Phosphorus is diffused into a thick slice of silicon with no previous
   phosphorus in it at a temperature of 1100°C. If the surface concentration of the
   phosphorus is 1×10^{18} atoms/cm³ and its concentration at 1 μm is 1×10^{15}
   atoms/cm³. How long does the diffusion process take? Diffusion coefficient equals
   3.0×10^{-17} m²/s for P diffusing in Si at 1100°C. (Hint: the solution of the
   time-dependent diffusion equation is an error function. The error function table
   given below might be used.)

erf (z)	z
0.9981	2.2
0.993	2.4

3. (20%) Please sketch npn bipolar transistor's minority carrier distribution under
   forward active and inverse active mode in each regions. Please also indicate
   space charge regions and thermal equilibrium minority carrier concentration
   levels on your graph.

4. (15%) What semiconductor material's properties can be measured by the Hall
   effect and briefly describe Hall effect measurements.

5. (15%) Please sketch the energy band diagram of an nN heterojunction in thermal
   equilibrium. Indicate conduction, valence band and Fermi level on your sketch.