

1. Explain the following in brief:
 - (a) Index system for crystal planes. (5%)
 - (b) Phonon. (5%)
 - (c) Kronig-Penny model. (5%)
 - (d) Stimulated emission. (5%)

2. A particle with mass m is confined to a two-dimensional box of length L and width $2L$.
 - (a) Find the energy values in terms of quantum numbers n_x and n_y . (15%)
 - (b) Find the lowest degenerate level. (5%)

3. In Si at 300K, at what donor concentration (N_D) is the probability of donor ionization equal to 90%? Assume the ionization energy of this dopant is 0.05eV, and the effective density of states in the conduction band (N_c) is $2.8 \times 10^{19} \text{cm}^{-3}$. (15%)

4. Suppose you could dope Si with any concentration of acceptors or donors. Assuming all dopants are ionized, is the least conductive silicon sample n-type, p-type, or intrinsic? Explain. (15%)

5. A Si p-n junction has a linearly graded junction on the n-side with $N_D = ax$ where $a = 10^{20} \text{cm}^{-4}$, and a uniform doping on the p-side with $N_A = 10^{16} \text{cm}^{-3}$. Suppose the depletion region width in the p-side is $0.5 \mu\text{m}$ at zero bias. Find the following at zero bias:
 - (a) the voltage drop across the depletion region. (15%)
 - (b) the junction capacitance if area is $100 \mu\text{m}^2$. (5%)

6. Draw the energy band diagrams of an ideal MOS diode in the following regime:
 - (a) depletion. (5%)
 - (b) inversion. (5%)