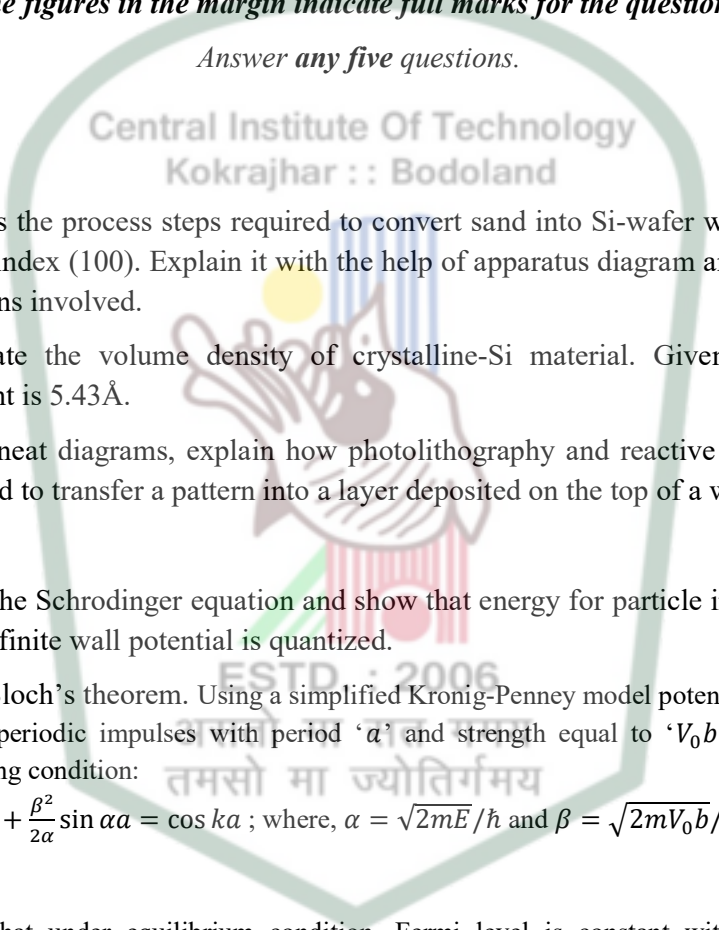## NOV 2024

ELECTRONIC DEVICES

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. a) Discuss the process steps required to convert sand into Si-wafer with a planar miller index (100). Explain it with the help of apparatus diagram and chemical reactions involved.   8

   b) Calculate the volume density of crystalline-Si material. Given its lattice constant is 5.43Å.   4

   c) Using neat diagrams, explain how photolithography and reactive ion-etching are used to transfer a pattern into a layer deposited on the top of a wafer.   8

2. a) Solve the Schrodinger equation and show that energy for particle in a 1-D box with infinite wall potential is quantized.   8

   b) State Bloch's theorem. Using a simplified Kronig-Penney model potential made out of 1D periodic impulses with period 'a' and strength equal to '$V_0 b$', derive the following condition: 2+10

   $$\cos \alpha a + \frac{\beta^2}{2\alpha} \sin \alpha a = \cos ka \text{ ; where, } \alpha = \sqrt{2mE}/\hbar \text{ and } \beta = \sqrt{2mV_0 b}/\hbar$$

3. a) Show that under equilibrium condition, Fermi level is constant with respect to position in a heterogeneous material. Using this fact, prove that the diffusivity-mobility ratio for holes, $\frac{D_p}{\mu_p} = \frac{K_B T}{|q|}$ (thermal voltage).   4+6

   b) Using reduced bandstructure diagram, explain the concept of effective mass for electrons.   4

   c) Show that the donor impurity level in an n-type Si crystal is mostly ionized at room temperature.   6

4. a) Determine the expression for small-signal depletion capacitance of a p-n junction when it is reverse biased. 6

   b) Derive the expression for current through a p-n junction when it is forward biased, assuming low-level injection of carriers. 10

   c) Using a neat energy band diagram, explain the operation of tunnel diode. 4

5. a) What are the different current components at each terminal for a p-n-p transistor when it is biased in Active mode? Derive the expression for collector current in this case assuming linear variation of minority carrier concentration in the base region. 4+6

   b) What is the difference between input resistances of Common-Base and common-Emitter configurations? Explain how a BJT can amplify small signals in active mode of operation. 6+4

6. a) Draw the energy-band diagram of a MOS capacitor when it is applied with a potential, $V_{GB} < 0$ Volts. Assume that the work functions for both the metal and semiconductor (p-type) as same. 5

   b) Derive the expression for drain current in an n-channel MOSFET in both Ohmic and Saturation mode of operation. 10

   c) Using energy-band diagram, distinguish between the operation of Ohmic and Schottky contacts. 5