

Level 3 Condensed Matter Physics- Part II

Weekly problem 2

(1) Silicon has a relative permittivity $\epsilon_r = 11.7$ and electron effective mass $m_e = 0.2m$. Calculate:

- i) the donor ionisation energy [1 mark]
- ii) the radius of the ground state orbit [1 mark]
- iii) the donor concentration at which the orbits begin to overlap [1 mark]

(2) A sample of silicon is purified until it contains only 10^{18} donors/m³. Below what temperature does it cease to show intrinsic behaviour? The band gap $E_g = 1.1$ eV and the intrinsic carrier concentration at 300 K is 5×10^{15} m⁻³. For simplicity assume that the effective density of states N_c and N_v are independent of temperature. [4 marks]

(3) 10^{20} atoms/m³ of phosphorus is added as dopant to pure silicon. What is the conductivity of the material at room temperature, assuming the sample is in the saturation regime? State any assumptions you make. The electron mobility in silicon is $0.16 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$. [3 marks]