351-2 Problems

1. An abrupt Si p-n junction has$N_a = 10^{18}cm^{-3}$ on one side and$N_d = 10^{15}cm^{-3}$on the other.
   (a) Calculate the Fermi level position at 300K on both sides.
   (b) Draw an equilibrium band diagram for the junction.
   (c) Determine the contact potentialΦ_o for this junction.
2. A silicon$p^+ - n$ junction$10^{-2}cm^2$ in area had$N_d = 10^{15}cm^{-3}$ doping on the n-side. Calculate the junction capacitance with a reverse bias of 10V.
3. For metallic aluminum, calculate:
   (a) The valence electron density.
   (b) The radius of the Fermi spherek_F.
   (c) Fermi energy in eV.
4. From the Schrodinger equation for a quantum well, show that the wave vector is equal to$n\pi/L$ where L is the well width.
5. Calculate the energy of light emitted from a 10 nm wide AlGaAs/GaAs quantum well structure that is photoexcited with 2.5 eV laser light.
6. What is the luminescent energy for a CdSe quantum dot with a 2 nm radius.
7. For a MOSFET device briefly describe how the three types of device work: a) enhancement mode b) depletion mode c) inversion mode.
8. Calculate the capacitance of an MOS capacitor with a 10 nm thickHfO_2 dielectric oxide. What is the ratio of capacitances forC_{HfO_2}/C_{SiO_2}. The relatie dielectric constant for$HfO_2$is 25.
9. Problem 9.9 in Solymar and Walsh
10. Problem 9.14 in Solymar and Walsh
11. Problem 9.16 in Solymar and Walsh
12. Problem 12.10 in Solymar and Walsh
13. Consider a quantum cascade laser (QCL) made from GaAs and GaAlAs. What well thickness is needed for laser emission at 3 microns?
14. Derive the expression for the average value of the dipole moment. Show that it is given by:
    $< \mu >= \mu[\coth a - \frac{1}{a}]$
15. The saturation polarizationP_s of$PbTiO_3$, a ferroelectric, is0.8 coulombs/m^2. The lattice constant is $4.1\dot{A}$. Calculate the dipole moment of unit cell.
16. Calculate the polarization P of one liter of argon gas at 273 K and 1 atm. The diameter of an argon atom is 0.3 nm.
17. Consider the frequency dependence of the atomic polarizability. The polarizability and its frequency dependence can be modeled as a damped harmonic oscillator. Derive the expression forα in this case.
    The expression is given by:
    $m\frac{dx}{dt^2} + b\frac{dx}{dt} + \omega_0^2 x = -e\varepsilon_{loc}\sin\omega t$
    Plotα vs.ω for this case.

18. Problem 4.6 in Solymar and Walsh.
19. Problem 4.7 in Solymar and Walsh.
20. Problem 4.8 in Solymar and Walsh.
21. Problem 4.9 in Solymar and Walsh.
22. Calculate the magnetic susceptibility of metallic copper. How does it compare to the measured value of -1.0?
23. Calculate the effective magneton number p forMn^{2+}, Co^{2+}. Show work.
24. Consider Mn doped GaP. There are$10^{20} Mn^{2+}$ ions.
25. What is the electron configurationMn^{2+} in spectroscopic notation.
    (a) Calculate its magnetic moment at saturation in Bohr magnetons.
    (b) Calculate its magnetic susceptibility.
26. For metallic Co, which has a Curie temperature of 1388 K, calculate the Weiss constantλ. Calculate the exchange constant in meV.