Assignment 6.1

Table 5.1 Selected typical properties of Ge, Si, and GaAs at 300 K

	E_g (eV)	χ (eV)	N_c (cm^{-3})	N_v (cm^{-3})	n_i (cm^{-3})	μ_e ($cm^2\ V^{-1}\ s^{-1}$)	μ_h ($cm^2\ V^{-1}\ s^{-1}$)	m_e^*/m_e	m_h^*/m_e	ε_r
Ge	0.66	4.13	1.04×10^{19}	6.0×10^{18}	2.3×10^{13}	3900	1900	0.12*a* 0.56*b*	0.23*a* 0.40*b*	16
Si	1.10	4.01	2.8×10^{19}	1.2×10^{19}	1.0×10^{10}	1350	450	0.26*a* 1.08*b*	0.38*a* 0.60*b*	11.9
GaAs	1.42	4.07	4.7×10^{17}	7×10^{18}	2.1×10^{6}	8500	400	0.067*a,b*	0.40*a* 0.50*b*	13.1

NOTE: Effective mass related to conductivity (labeled *a*) is different than that for density of states (labeled *b*). In numerous textbooks, n_i is taken as 1.45×10^{10} cm^{-3} and is therefore the most widely used value of n_i for Si, though the correct value is actually 1.0×10^{10} cm^{-3}. (M. A. Green, *J. Appl. Phys.*, **67**, 2944, 1990.)

Question 1: Using the values of the density of states effective masses m_e* and m_h* in Table 5.1, calculate the intrinsic concentration in Ge at *400K.*

What is n_i if you use N_c and N_v from Table 5.1 at 300K?

Calculate the intrinsic resistivity of Ge at 300 K.

Question 2: Using the values of the density of states effective masses m_e* and m_h* in Table 5.1, find the position of the Fermi energy in intrinsic GaAs with respect to the middle of the bandgap ($E_g/2$).

Question 3: A Si crystal has been doped with P. The donor concentration is 10^{15} cm^{-3}. Find the conductivity, and resistivity of the crystal at room temperature (300 K).

Question 4:

a) From Table 5.1, calculate the expected doping concentration of a p-type Si semiconductor with a resistivity of 1 Ω·cm at room temperature, assuming the electron and hole drift mobility remain unchanged.
b) What is the change in the Fermi energy of the p-type Si compared to intrinsic Si?

Question 5:

Schematically draw the energy diagram, density of states, Fermi-Dirac probability, and carrier distributions of a *p-type* semiconductor.