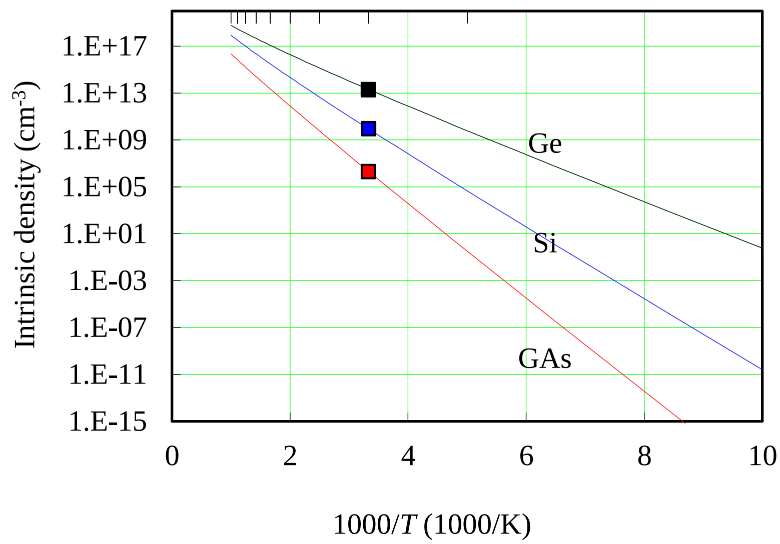
ECE 447/547 (Semiconductor Devices)
Southern Illinois University at Carbondale

Homework 05

Q1. (E_g characterization: 25 points)
Intrinsic carrier concentration, n_i, of a semiconductor sample is given by:

$$n_i = \sqrt{N_C N_V} \exp\left(-\frac{E_g}{2kT}\right).$$

The $\log(n_i)$ *vs.* $\frac{1000}{T}$ characteristic of Si, Ge, and GaAs are shown in the Figure. Extract the bandgap for these materials.
Given: $kT = 0.026$ eV (at $T = 300$K).



Q2. Silicon at $T = 300$ K is doped with arsenic atoms such that the concentration of electrons is $\boldsymbol{n_0 = 5 \times 10^{17}}$ cm^{-3}. (a) Find E_c -E_F. (b) Determine E_F-E_v. (c) Calculate p_0. (d) Which carrier is the minority carrier? (e) Find E_F-E_i.

Q3. Consider a sample of silicon doped at $N_a = 0$ and $N_d = 10^{15}$ cm^{-3}. Using an suitable programming/graphing toolkit, plot the majority carrier concentration versus temperature over the range $100 \leq T \leq 600\ K$.

Q4. A new semiconductor material is to be "designed." The semiconductor is to be p type and doped with 5×10^{15} cm^{-3} acceptor atoms. Assume complete ionization and assume $N_d = 0$. The effective density of states functions are $N_c = 1.2 \times 10^{19}$ cm^{-3} and $N_v = 1.8 \times 10^{19}$ cm^{-3} at $T = 300$ K and vary as T^2. A special semiconductor device fabricated with this material requires that the hole concentration be no greater than 5.08×10^{15} cm^{-3} at $T = 350$ K. What is the minimum bandgap energy required in this new material?