1) Using the energy band model for a semiconductor, explain how you visualize:
   (a) An electron.  (b) A hole.  (c) Donor sites
   (d) Acceptor sites.  (e) An intrinsic e extrinsic semiconductor
   (f) An n-type semiconductor  (g) A P-type semiconductor

2) (a) 1 ev is equal to how many Joules of energy?
   (b) \( kT \) is equal to how many ev at 300 K?
   (c) At 300 K, \( \frac{kT}{q} = ? \)
   (d) \( E_g (Si) = ? \)
   (e) \( E_g (GaAs) = ? \)
   (f) The ionization energy (1eV) of phosphorus site
      in Si is equal to?

3) Given that \( n_i = 1.02 \times 10^{10} \) /cm\(^3\) at \( T=300 \) K, calculate \( n_i \) at \( T=200 \) K, and \( T=150 \) K, assuming \( E_g (Si) = 1.12 \text{ev at all temperature} \).

4) A piece of Si is doped with \( 2 \times 10^{15} \) /cm\(^3\) phosphorus atoms. What are the majority and minority carrier concentration at 300 K?

5) Suppose that the hole concentration in a piece of Si at room temperature is \( 10^5 / \text{cm}^3 \), find:
   (a) The electron concentration.  (b) The location of the Fermi energy.

6) A sample of Si is first doped with \( 10^{15} / \text{cm}^3 \) Boron atoms, and then doped with \( 4 \times 10^{15} / \text{cm}^3 \) Arsenic atoms.
   (a) What is the type of semiconductor?
   (b) Find the location of the Fermi energy.

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7) If we assume that $m_e = m_v = m_0$, find the density of valence band ($N_V$), and the density of conduction band ($N_C$).

8) For Si sample at $T = 300 \text{K}$, the Fermi level is located at 0.26 eV above the intrinsic Fermi level. What are the hole and electron concentrations?

9) In an $n$-type semiconductor, the temperature is lowered such that only half the donor atoms are ionized. Neglecting the degeneracy factor, show that

$$E_F = kT \ln \left(\frac{N_D}{2 N_C}\right) + E_C$$

10) In an extrinsic semiconductor, say $n$-type, at higher temperature the electrons come from ionization of the donor atoms as well as from excitation of electrons from the valence band to the conduction band. If $N_D^+$ is the donor density, show that the intrinsic carrier density, at the temperature at which the electron density is twice that of the hole density, is $\sqrt{2} N_D^+$. 