本試題是否可以使用計算機：☑可使用　□不可使用　（請命題老師勾選）

1. Assume the Fermi energy level is 0.35 eV above the valence band energy and $T = 300$ K.
   (a) Determine the probability of a state being empty of an electron at E_v. (5%)
   (b) Repeat part (a) for an energy state at $E_v - kT$. (5%)

2. The Schottky barrier height of a silicon Schottky junction is $\phi_{Bn} = 0.59$ eV, the effective Richardson constant is $A^* = 114$ A/K^2-cm^2, the cross-sectional area is $A = 10^{-4}$ cm^2. For $T = 300$ K, calculate
   (a) The ideal reverse-saturation current. (5%)
   (b) The diode current for $V_a = 0.30$ V. (5%)

3. Consider an n-P heterojunction in thermal equilibrium. Derive the following equation

$$W = \left\{ \frac{2\varepsilon_n \varepsilon_P \left(N_{dn} + N_{aP}\right)^2 V_{bi}}{eN_{dn}N_{aP}\left(\varepsilon_n N_{dn} + \varepsilon_P N_{aP}\right)} \right\}^{1/2}$$

   for the total depletion width W of an abrupt heterojunction, where ε_n and ε_P are the permittivities of the n and P materials, N_{dn} and N_{aP} are the donor and the acceptor dopant densities of the n and P materials, respectively, e is the electron charge, and V_{bi} is the total built-in potential barrier. (20%)

4. An ideal n-channel MOSFET has the following parameters:

   $W = 30$ μm　　$\mu_n = 450$ cm^2/V-s　　$L = 2$ μm
   $t_{ox} = 350$ Å　　$V_T = +0.80$ V

   The gate terminal is connected to the drain terminal. Fill out the following table for I_D versus V_{DS} in the range of $0 \le V_{DS} \le 5$ V. (10%)

V_{DS} (V)	0	1	2	3	4	5
I_D (mA)						

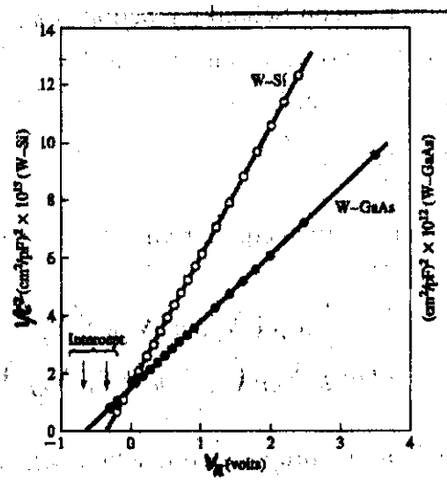
5. If 3×10^{15} gold atoms per cm^3 are added to silicon as a substitutional impurity and are distributed uniformly through out the semiconductor, determine the distance between gold atoms in terms of the silicon lattice constant, assuming the gold atoms are distributed in a cubic array. The lattice constant a of the silicon is 5.43 Å. (10%)

6. Consider an optical cavity of a laser diode. Show that
   (a) The wavelength separation between two adjacent resonant modes is $\Delta\lambda = \lambda^2/2L$. (10%)
   (b) If the photon output of a laser diode is equal to the bandgap energy, find the wavelength separation between adjacent resonant modes in a GaN laser with $L = 100$ μm (hint: bandgap

（背面仍有題目，請繼續作答）

energy for GaN is ~3.4 eV). (10%)

7. Consider the $1/C^2$ versus V_R curve for W-Si Schottky barrier diode. Calculate (a) the semiconductor doping (5%) and (b) Schottky barrier height from the silicon diode experimental data shown below. Assume T = 300 K. (5%)



8. Consider a pn junction GaN LED. Assume that photons are generated uniformly in all directions in a plane perpendicular to the junction at a distance of 0.50 μm from the surface.
   (a) Taking the total internal reflection into account, calculate the fraction of photons that have the potential of being emitted from the semiconductor. (5%)
   (b) Using the results of part (a) and including Fresnel loss, determine the fraction of generated photons that will be emitted from the semiconductor into air (neglect absorption losses). (5%)