請在答案卷內作答

1. For a material of with E-k diagram shown in **Figure 1**, there are two different effective masses (heavy / light) for electrons. Which effective mass will be the one displayed by most electrons in the conduction band? Explain why? (10%)

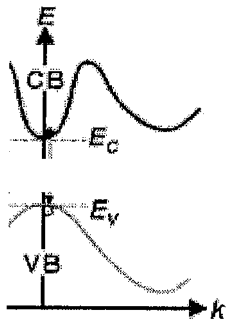

Figure 1

2. (a) Please draw two curves of electron mobility vs. temperature (K) in log-scale for two Si samples, A and B with uniform doping concentrations of N_{D1}, N_{D2}, respectively, where $N_{D1} < N_{D2}$. Please label A and B on the plot. (10%) (b) Sample B is counter-doped uniformly with N_A, becoming sample C. Draw its mobility vs. temperature curve on the same plot in (a) and explain the differences in the 3 corresponding curves. (10%)

3. We deposit a metal with a work function of 4.6 eV on Si at room temperature. Suppose that the Si has an electron affinity of 4 eV and a doping concentration of 10^{17} cm^{-3}. Please draw the equilibrium band diagrams of this M-S junction if (a) the doping is n-type and (b) the doping is p-type, respectively. (20%)

4. Consider a uniformly doped Si NPN BJT. For the emitter and base regions, assume equal region widths (x_E=x_B), diffusion lengths (L_E=L_B), and minority carrier lifetimes (τ_E=τ_B). With doping concentrations N_B=10^{17} cm^{-3} and N_E=10^{19} cm^{-3}, please calculate the emitter injection efficiency when the bandgap narrowing effect is neglected. (15%)

5. Consider a MOS capacitor fabricated on an n-type silicon. The charge diagrams for this MOS capacitor under various bias conditions are shown in diagram (1)-(5) of **Figure 2**.
   (a) Which charge diagram corresponds to accumulation condition? (3%)
   (b) Which charge diagram corresponds to depletion condition? (3%)
   (c) Which charge diagram corresponds to strong-inversion condition? (3%)

請在答案卷內作答

(d) Which charge diagram corresponds to flat-band condition? (3%)

(e) Which charge diagram corresponds to threshold condition? (3%)

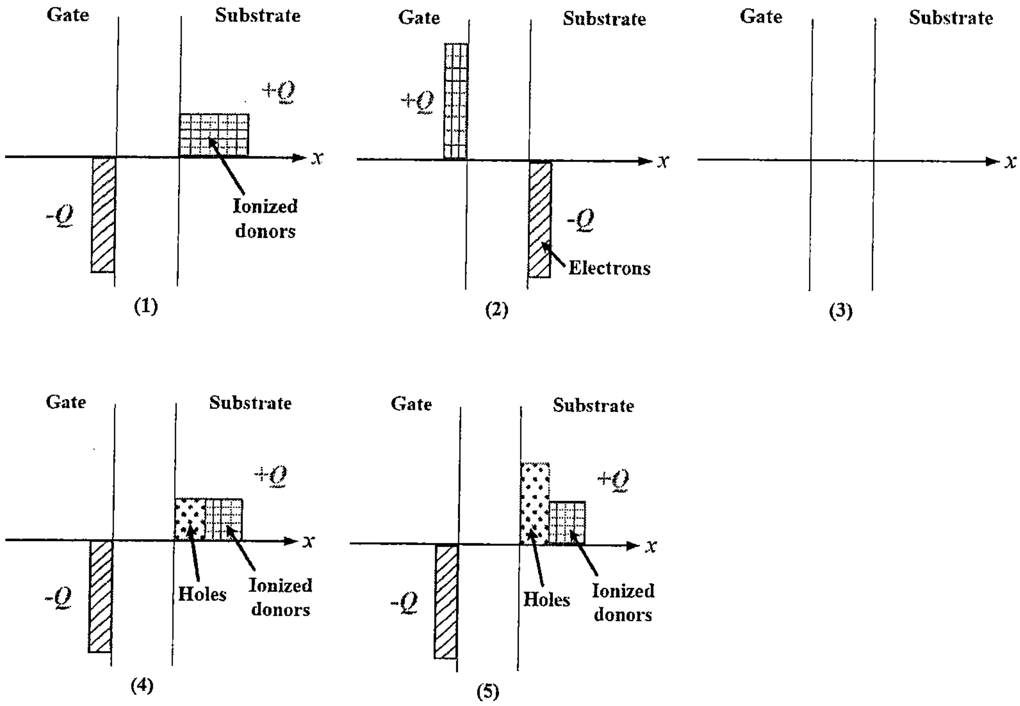

Figure 2

6. For an NMOSFET, assume that the gate oxide thickness t_{ox} = 277 Å, the channel length L = 1 μm, the channel width W = 10 μm, and the threshold voltage V_T = 1 V and the saturation velocity of the electron v_{sat} = 8 × 10^6 cm/s. The output characteristics of the transistor with V_{GS} = 5 V were measured and three data points are given here. Note that $I_D = WQ_n(y)v(y)$ and that we have C_{ox} = 1.25 F/m^2 for t_{ox} = 277 Å

   (a) What are the electron velocities at the source end of the channel and at the drain end of the channel for data point A, V_{DS} = 0.5 V, I_D = 1.0 mA? (5%)

   (b) What are the electron velocities at the source end of the channel and at the drain end of the channel for data point B, V_{DS} = 2.5 V, I_D = 2.5 mA? (5%)

   (c) What are the electron velocities at the source end of the channel and at the drain end of the channel for data point C, V_{DS} = 5.0 V, I_D = 2.75 mA? (5%)

   (d) It appears from above findings that the drain current saturated well before V_{DS} reach $V_{Dsat} = V_{GS} - V_T$ = 4 V as predicted by the basic MOSFET I-V model. Why does the current saturation happen before V_{DS} = 4.0 V? (5%)