1. (15%) A Si *p-n* junction diode with a cross-sectional area of 3×10^{-4} cm^2. The parameters of the diode are: acceptor concentration $N_A = 6 \times 10^{16}$ cm^{-3}, donor concentration $N_D = 2 \times 10^{16}$ cm^{-3}, intrinsic carrier concentration $n_i = 9.65 \times 10^9$ cm^{-3}, diffusion constant of electrons $D_n = 21$ cm^2/s, diffusion constant of holes $D_p = 10$ cm^2/s, carriers lifetime: $\tau_p = \tau_n = 5 \times 10^{-7}$ s. (i) Calculate the built-in voltage at 300 K. (5%) (ii) Calculate the ideal reverse saturation current. (10%)

2. (10%) Consider an n-channel enhancement-mode MOSFET with the following parameters: threshold voltage $V_{TN} = 0.75$ V, channel width $W = 100$ μm, channel length $L = 10$ μm, electron mobility $\mu_n = 650$ cm^2/V-s, oxide thickness $t_{ox} = 500$ Å, and oxide permittivity $\varepsilon_{ox} = (3.9)(8.85\times10^{-14})$ F/cm. (i) Determine the drain current when $V_{GS} = V_{DS} = 2.5$ V, for the transistor biased in the saturation region. (5%) (ii) Determine the drain current when $V_{GS} = 2.5$ V and $V_{DS} = 1$ V, for the transistor biased in the triode (non-saturation) region. (5%)

3. (25%) In the circuit shown in Figure 1, the transistor has a β of 250. (i) What is the dc voltage at the collector? (5%) (ii) Find the input resistances R_{ib} and R_{in} and the overall voltage gain (v_o/v_{sig}). (15%) (iii) For an output signal of ±0.5 V, what values of v_{sig} and v_b are required? (5%)

4. (18%) Analyze the circuit of Figure 2 to determine the small-signal voltage gain V_o/V_s, the input resistance R_{in}, and the output resistance $R_{out} = R_{of}$. The transistor has $\beta = 100$.

5. (18%) Find the voltage gain v_O/v_{Id} for the difference amplifier of Figure 3 for the case $R_1 = R_3 = 10$ kΩ and $R_2 = R_4 = 100$ kΩ. What is the differential input resistance R_{id}? If the two key resistance ratios (R_2/R_1) and (R_4/R_3) are different from each other by 1%, what do you expect the common-mode gain A_{cm} to be? Also, find the CMRR in this case.

6. (14%) A BJT is specified to have a maximum power dissipation P_{D0} of 2 W at an ambient temperature T_{A0} of 25°C, and a maximum junction temperature T_{Jmax} of 150°C. Find the following: (a)The thermal resistance θ_{JA}. (5%) (b) The maximum power that can be safely dissipated at an ambient temperature of 50°C. (5%) (c) The junction temperature if the device is operating at $T_A = 25$°C and is dissipating 1 W. (4%)

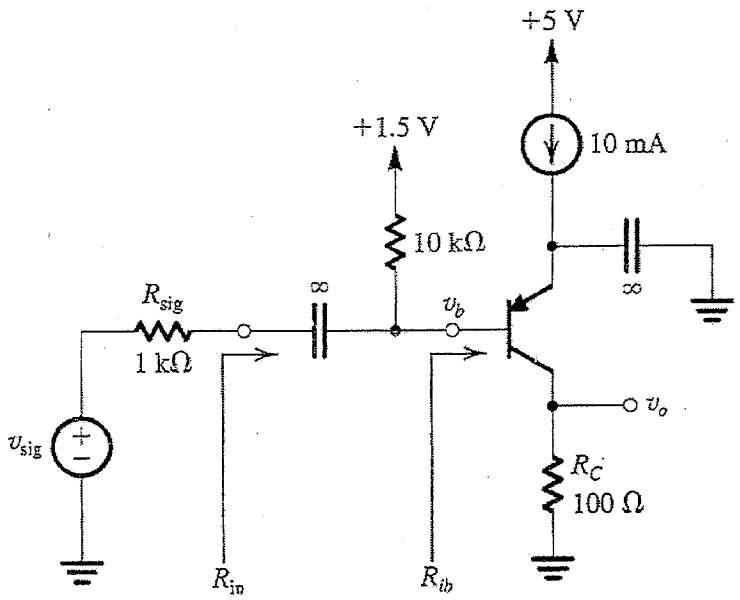

Figure 1

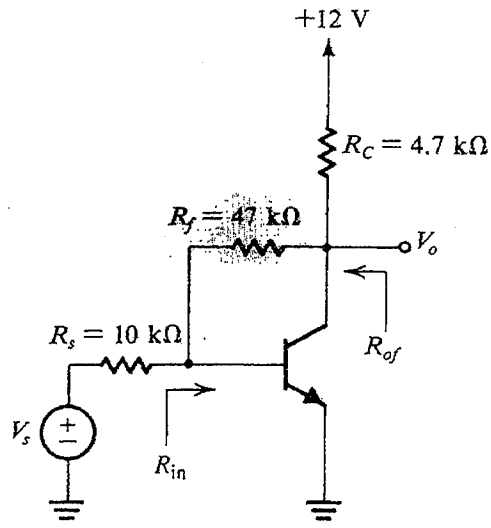

Figure 2

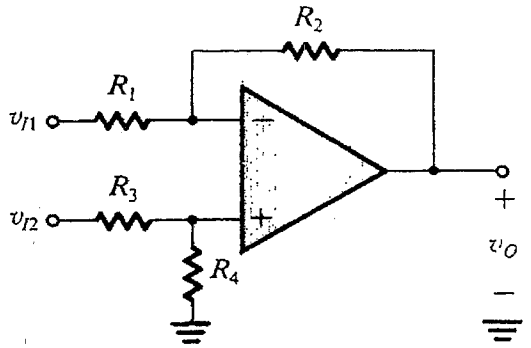

Figure 3