1. Find the output function of the following instrument amplifier. (10 points)

![Instrument Amplifier Diagram]

2. For the following ideal OPA circuit, assume the input signal frequency is 159kHz, find the output voltage gain $\frac{V_o}{V_i}$ in dB. (10 points)

![OPA Circuit Diagram]
3. For the following CE amplifier, assume the transistor internal parameters are \( r_x = 10\,\Omega, C_w = 8\,\text{pf}, C_\mu = 1\,\text{pf} \), and the coupling capacitors are \( C_1 = 10\,\mu\text{F}, C_2 = 10\,\mu\text{F}, C_E = \infty \), evaluate the following: (20 points)

a. The upper corner frequency \( \omega_H \).

b. The lower corner frequency \( \omega_L \).

c. The midband voltage gain \( A_m = \frac{v_o}{v_s} \) and the bandwidth BW.

d. Sketch the bode diagram \( \frac{v_o}{v_s} \).

4. For the following MOSFET amplifier, assume the transistor parameters are:

\[
V_i = 1.5V, \frac{\mu_n C_{ox} W}{L} = 0.25mA/V^2, V_A = 50V.
\]

(20 points)

a. Determine the small signal parameters \( g_m \) and \( r_o \).

b. Determine the input and output resistance \( R_i \) and \( R_o \).

c. Determine the open circuit voltage gain \( A_{vo} \).

d. Determine the short circuit current gain \( A_{is} \).
5. For the following BJT differential amplifier, find the following: (25 points)

   a. The input differential resistance $R_{id}$.

   b. The overall differential voltage gain $\frac{v_o}{v_s}$ (neglect the effect of $r_o$).

   c. The worst case common mode gain if the two collector resistances are accurate to within $\pm 5\%$.

   d. The CMRR in dB.

   e. The input common-mode resistance $R_{icm}$ (assuming that the Early voltage $V_A = 100V$).
6. True and false (you have to justify your answers.) (3 points for each)
   a. There are two types of carriers in a semiconductor. The holes drift current direction is opposite to that of the applied electric field. But the electrons drift current is in the same direction of the applied electric field.
   b. The diffusion current in a semiconductor is relational to the concentration gradient. The following electron concentration can drive the diffusion current in the x direction.
   c. The totem pole TTL gate is popularly used, since the gate output can be connected as wire AND.
   d. The PIV (peak inverse voltage) of the bridge rectifier is about half the value for the center-tapped full-wave rectifier.
   e. The negative feedback amplifier can reduce the closed-loop gain and the nonlinear distortion.