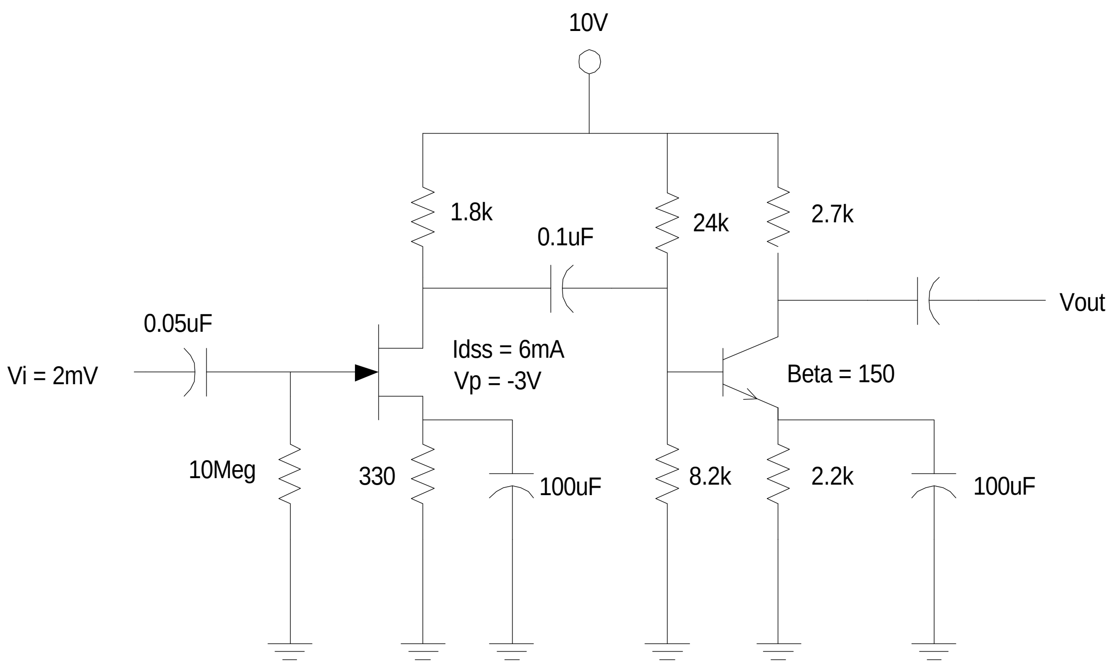
For the following cascade amplifier, calculate the DC bias voltages, the collector currents of each stage, the voltage gain of each stage, the overall amplifier gain, the input impedance, and the output impedance.



Solution

DC Analysis:

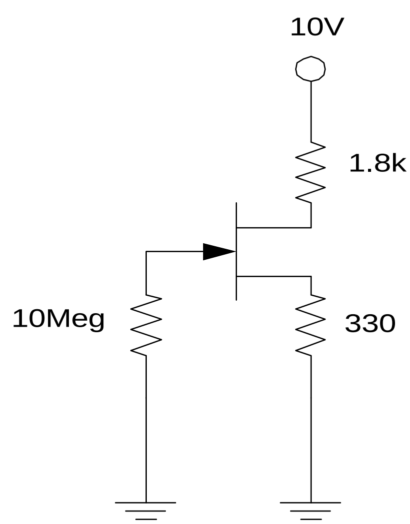
$$V_{gsq} = -0.95\text{V (see graph)}$$

$$I_{dq} = 2.8\text{mA (see graph)}$$

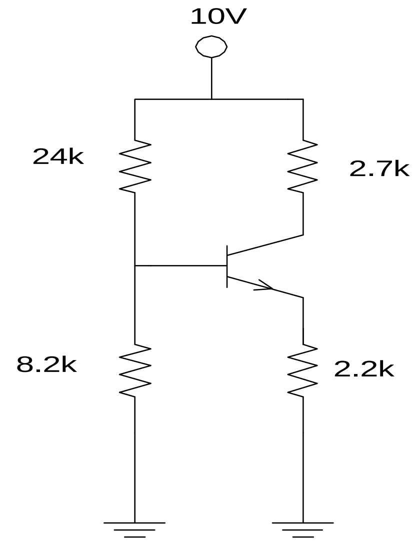
$$V_d = 10\text{V} - (2.8\text{mA})(1.8\text{k}) = 4.96\text{V}$$

$$V_s = (2.8\text{mA})(330) = 924\text{mV}$$

$$V_g = 0\text{V}$$

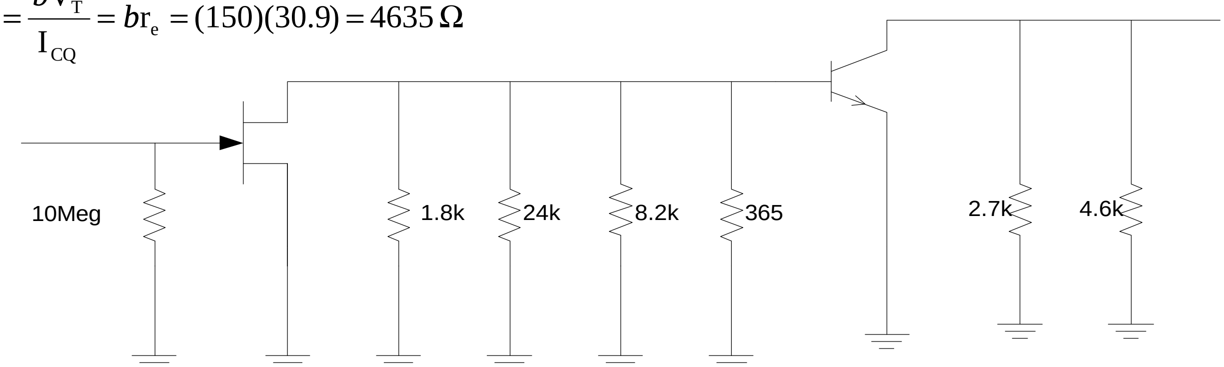


$$V_b = \frac{10V(8.2k)}{24k + 8.2k} = 2.55V$$
$$V_e = 2.55V - 0.7V = 1.85V$$
$$I_e = \frac{1.85V}{2.2k} = 0.84mA = I_c$$
$$V_c = (2.7k)(0.84mA) = 2.27V$$
$$I_b = \frac{1}{150}\left(0.84mA\right) = 5.6uA$$



AC Analysis:

$$r_e = \frac{V_T}{I_{CQ}} = \frac{26mV}{0.84mA} = 30.9\,\Omega$$
$$r_p = \frac{bV_T}{I_{CQ}} = br_e = (150)(30.9) = 4635\,\Omega$$



$$g_m = \frac{2(I_{DSS})}{|V_P|}\left(1 - \frac{V_{GS}}{V_P}\right)^2 = \frac{2(6mA)}{3}\left(1 - \frac{-0.95}{-3}\right) = 2.73\,x\,10^{-3}\text{ mho}$$
$$r_d = \frac{1}{g_m} = 365\Omega$$
$$A_{V(FET)} = -g_m(r_o \,\|\, R_D \,\|\, R_L \,\|\, r_d)$$
$$A_{V(FET)} = (-2.73\,\text{mho})(1.8k \,\|\, 24k \,\|\, 8.2k \,\|\, 365\Omega) = (289\,\Omega)(-2.73\,x\,10^{-3}\text{ mho}) = -0.79$$
$$A_{V(BJT)} = \frac{-(b)(R_C \,\|\, rp)}{rp} = \frac{-(150)(2.7k \,\|\, 4.6k)}{4.6k} = -55$$
$$A_{V(Total)} = (A_{V1})(A_{V2}) = (-0.79)(-55) = 43.75$$
$$R_{in} = 10M\Omega$$
$$R_{Out} = 2.7k$$

Graph of I_d (mA) vs. V_{gs} (V)

$$I_d = 6mA\left(1 - \frac{V_{gs}}{-3}\right)^2$$