,

P1- β=150 and $|V_{BE}|\cong 0.6V$ are given for the transistors in Figure-1a ($V_T\cong 25mV$)
a) Vo=0V is required for Vi=0V. Find I_{C1}, I_{C2} and R_{C2}. (Transistors are in the active mode)

b)Figure-1b shows simplified ac model of the circuit. Find ri, Gv and ro.

c) An ac voltage source Vg that has a serial resistance Rg of 1k, is connected to the input of the circuit and a load resistance R_Y of 2.2k to the output. Find ac gain vo/vg.

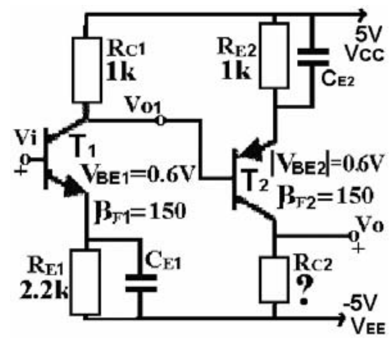

Figure-1a

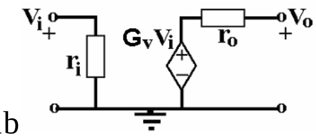

Figure-1b

Solution:
a)
Two ways given in Figure-S11 can be used for obtaining the transistor collector currents.

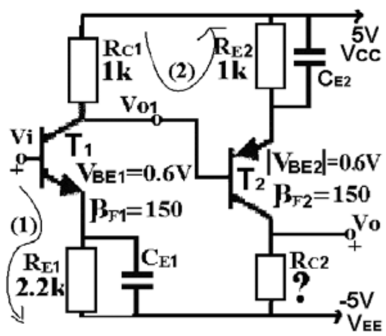

Figure-S11

From (1)

$$V_i - V_{BE1} - I_{E1}R_{E1} = -5$$

$$0 - 0.6\text{V} - (\beta+1)I_{B1}R_{E1} = -5$$

$$\Rightarrow I_{B1} = \frac{4.4V}{(\beta+1)R_{E1}} = 13.25\mu A \Rightarrow I_{C1} = \beta I_{B1} \cong 2mA$$

From(2)

$$(I_{C1} - I_{B2})R_{C1} = I_{E2}R_{E2} + |V_{BE2}|$$

$$\Rightarrow (I_{C1} - I_{B2})R_{C1} = (\beta+1)I_{B2}R_{E2} + |V_{BE2}|$$

$$\Rightarrow (2mA - I_{B2})1k = (150+1)I_{B2}1k + 0.6V$$

$$\Rightarrow I_{B2} = \frac{2V - 0.6V}{152k} = 9.2\mu \Rightarrow I_{C2} = \beta I_{B2} \cong 1.4mA$$

$$V_{RC2} = V_O - V_{EE} = 5V \Rightarrow I_{RC2} = I_{C2} \Rightarrow R_{C2} = \frac{5V}{1.4mA} \cong 3.6k$$

b) ri: ac input resistance of the circuit ro: ac output resistance of the circuit
G_v: ac gain (vo/vi) of the circuit without a load.

Ac case of the circuit is given in-Figure-S12.
Thus:

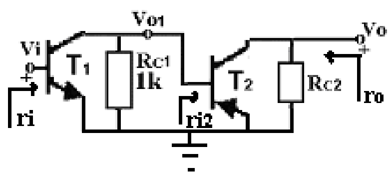

Figure-S12

$$r_i = (\beta+1)\frac{1}{g_{m1}} = 151\frac{v_T}{I_C} \cong 1.9k$$

$$r_0 = R_{C2} = 3.6k$$

$$G_V = \frac{v_{O1}}{v_i}\frac{v_O}{v_{O1}} = \frac{v_{C1}}{v_{b1}}\frac{v_{C2}}{v_{b2}} = \frac{-g_{m1}R_{c1}}{1+g_{m1}R_{e1}}\frac{-g_{m2}R_{c2}}{1+g_{m2}R_{e2}}$$

$$g_{m1} = \frac{I_{C1}}{v_T} = 80mS \qquad R_{c1} = R_{C1} // r_{i2} \qquad r_{i2} = (\beta+1)\frac{1}{g_{m2}} = 2.7k \qquad R_{c2} = R_{C2}$$

$$g_{m2} = \frac{I_{C2}}{v_T} = 56mS \qquad R_{e1} = 0 \qquad R_{e2} = 0$$

$$G_V = \frac{-g_{m1}R_{c1}}{1+g_{m1}R_{e1}}\frac{-g_{m2}R_{c2}}{1+g_{m2}R_{e2}} = \frac{-g_{m1}R_{C1}//r_{i2}}{1}\frac{-g_{m2}R_{C2}}{1} = (-58)(-201)) = 11.658$$

c)

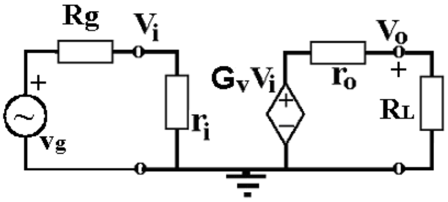

Figure-S13

From Figure-S13: $\frac{v_O}{v_g} = \frac{v_i}{v_g}\frac{v_O}{v_i} = \frac{r_i}{r_i+R_g}\frac{G_V R_L}{r_O+R_L} \cong 2900$

****

Q5- For the transistors employed in the circuit given in Figure-5 β=100 and $|V_{BE}| \cong 0.6$V are given ($V_T \cong 25$mV).

a) Find DC collector current values of the transistors.

b)Find CMRR of the circuit.

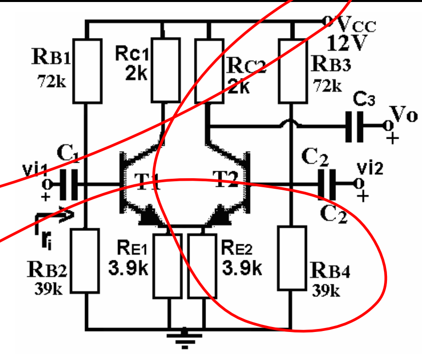

Figure-5

Solution:

a)The transistors have the same DC values, therefore the circuit can be solved as two parts given in Figure-S41.

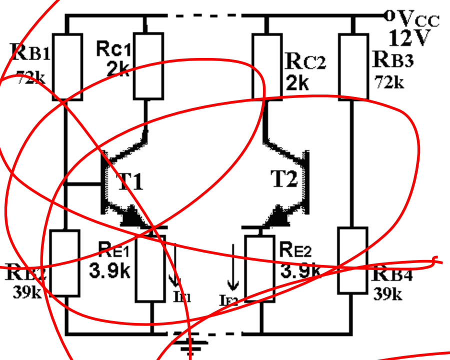

Figure-S41

From Figure-S41 (using Thevenin Theorem for R_{B1} and R_{B2}):

$$I_{C1} = \beta\frac{\frac{R_{B2}}{R_{B2}+R_{B1}}V_{CC} - V_{BE1}}{R_{B1}//R_{B2}+(\beta+1)R_{E1}} = 100\frac{3.61V}{25.3k+101x3.9k} = 0.86mA = I_{C1} = I_{C2}$$

b) $CMRR = \frac{1}{2} + g_m R_{EE} = \frac{1}{2} + \frac{I_{C1}}{V_T}R_{E1}//R_{E2} \cong 68$

****

Q-6 a) In a doped semiconductor, the ion concentration is approximately equal to the doping concentration. Explain the semiconductor type (N or P). (5Points)

A6a)

N type-semiconductor

When a semiconductor is doped as N-type, the donor atoms are used and each donor atom gives one electron to the semiconductor medium. After giving one electron, the donor atom becomes an ion. On the other hand, the hole concentration is very low when compared to the doping concentration (which is approximately equal to the free electron concentration). One hole means one silicon ion. Thus the silicon ion concentration is very low when compared to the doping concentration. As a result, in an N-type doped semiconductor the ion concentration is approximately equal to the doping concentration.

b) Explain why BJTs give more gain when compared to MOSFETs (5P)
The current-voltage relationship of a BJT shows an exponential characteristic, on the other hand the relationship of a MOSFET shows a square-law characteristic. As known, derivative of an exponential function is higher than that of a square-law function. Thus, BJTs have grater g_m values when compared to MOSFETs. As a result, BJTs give more gain.