

22. A two stage circuit is shown in Figure 5. It's BJT parameters are  $\beta_1 = \beta_2 = 200$ , [10]  
 $V_{BE1} = V_{BE2} = 0.7V$

- a) Calculate the DC parameters of the circuits i.e  $V_{B1}$ ,  $V_{B2}$ ,  $V_{E1}$ ,  $I_{E1}$ ,  $I_{C1}$ ,  $I_{C2}$ ,  $I_{E2}$ ,  $V_{C1}$ ,  $V_{C2}$ ,  $V_{E2}$ ,  $V_{CE1}$  &  $V_{CE2}$
- b) Calculate input impedance of the circuit
- c) Calculate output impedance of the circuit
- d) Calculate voltage gain for the circuit

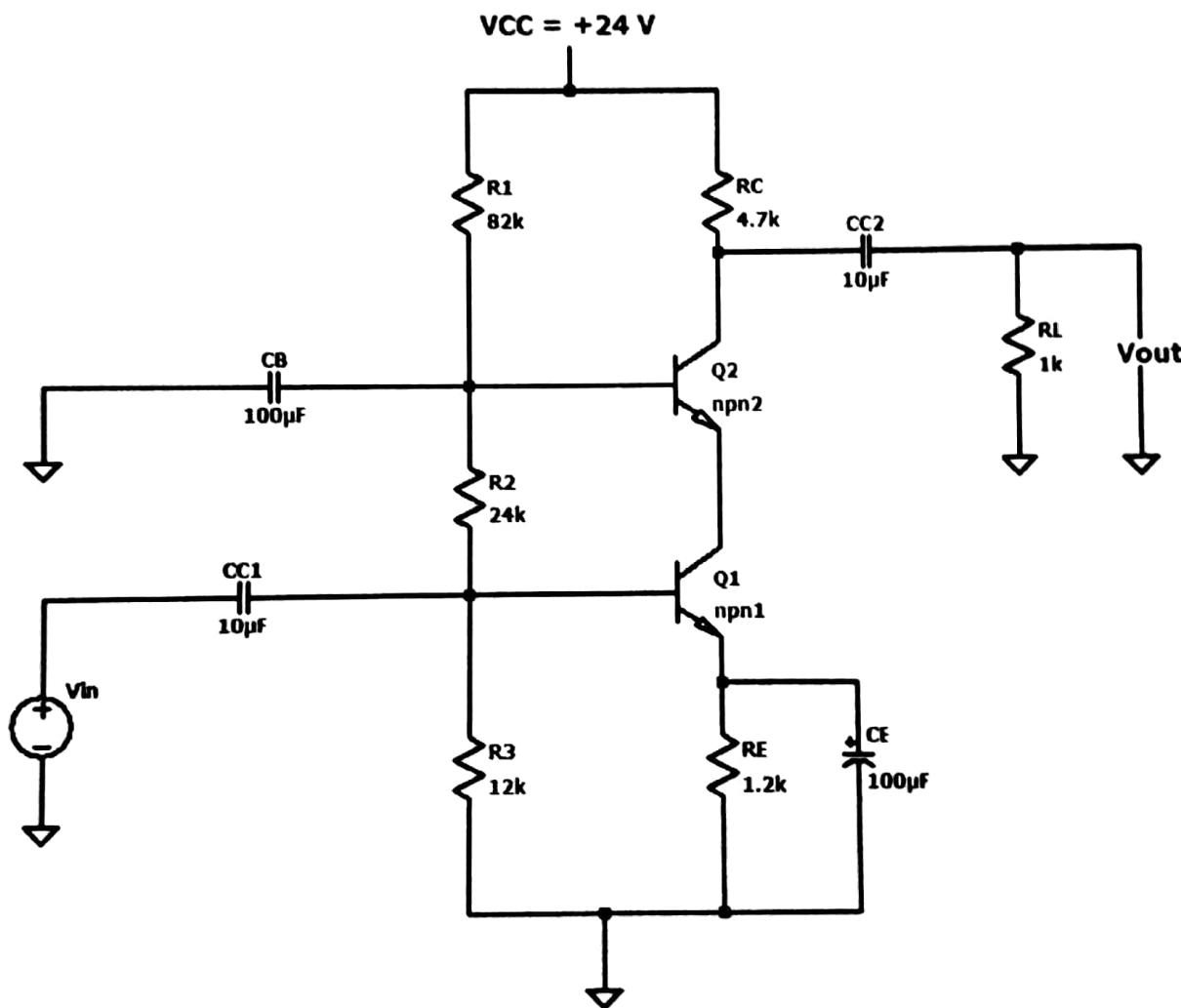
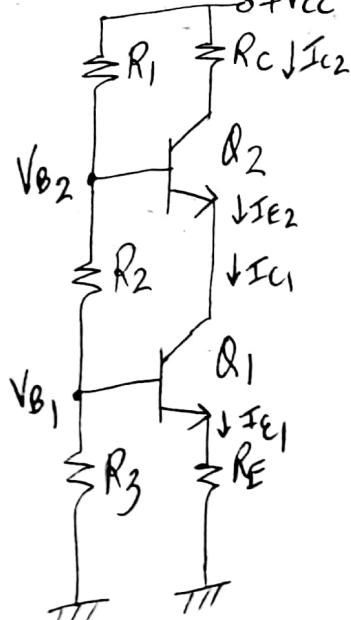


Figure 5: Question 22

Answers:  $V_{B1} = 2.44V$     $V_{B2} = 7.32V$     $V_{E1} = 1.74V$     $I_{E1} = 1.45mA$   
 $I_{C1} = 1.45mA$     $I_{C2} = 1.45mA$     $I_{E2} = 1.45mA$     $V_{C1} = 6.62V$     $V_{C2} = 17.18V$   
 $V_{E2} = 6.62V$     $V_{CE1} = 4.88V$     $V_{CE2} = 10.56V$     $g_{m1} = g_{m2} = 55.77mA/V$   
 $r_{\pi 1} = r_{\pi 2} = 3.586k\Omega$     $Z_i = 2.476k\Omega$     $Z_o = 824.56\Omega$     $A_{V1} = -0.9949$   
 $A_{V2} = 45.98$     $A_{VT} = -45.75$

Solution: DC Analysis



$$R_T = R_1 + R_2 + R_3 = 82K + 24K + 12K = 118K \Omega$$

$$\rightarrow V_{B1} = \frac{R_3}{R_T} \times V_{CC} = \frac{12K}{118K} \times 24 = 2.44V$$

$$\rightarrow V_{B2} = \frac{R_2 + R_3}{R_T} \times V_{CC} = \frac{36K}{118K} \times 24 = 7.322V$$

$$\rightarrow V_{E1} = V_{B1} - V_{BE1} = 2.44 - 0.7 = 1.74V$$

$$\rightarrow I_{E1} = \frac{V_{E1}}{R_E} = \frac{1.74}{1.2K} = 1.45mA$$

$$\rightarrow I_{E1} = I_{C1} = I_{E2} = I_{C2} = 1.45mA$$

$$\rightarrow V_{C_2} = V_{CC} - I_{C_2} R_C$$

$$= 24 - 1.45mA \times 4.7K$$

$$= \underline{17.185V}$$

$$\rightarrow V_{E_2} = V_{B_2} - V_{BE_2}$$

$$= 7.322 - 0.7$$

$$= \underline{6.622V}$$

$$\rightarrow V_{C_1} = V_{E_2} = \underline{6.622V}$$

$$\rightarrow V_{CE_1} = V_{C_1} - V_{E_1} = 6.622 - 1.74 = \underline{4.882V}$$

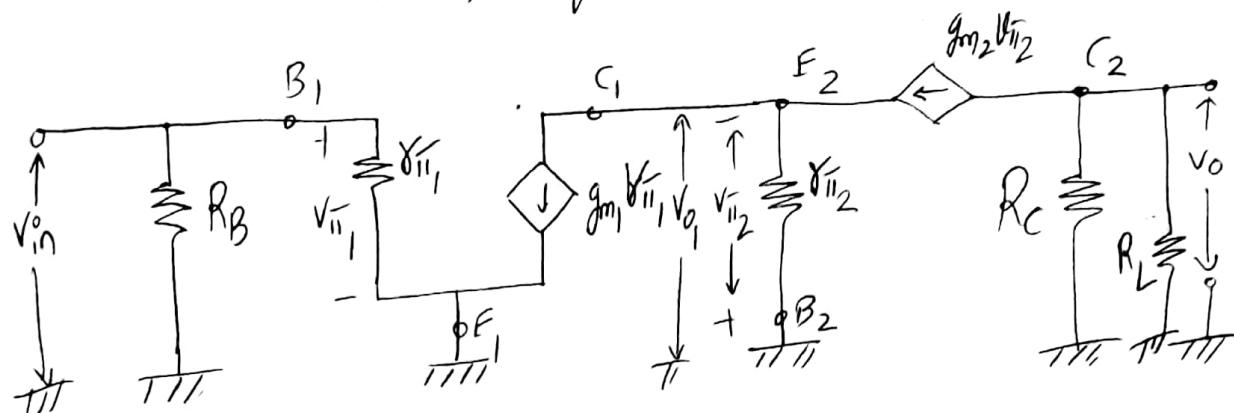
$$\rightarrow V_{CE_2} = V_{C_2} - V_{E_2} = 17.185 - 6.622 = \underline{10.56V}$$

Small-signal parameters :-

$$\rightarrow \gamma_{11} = \gamma_{112} = \frac{\beta V_T}{I_{CQ}} = \frac{200 \times 26mV}{1.45mA} = \underline{3.586K_S2}$$

$$\rightarrow g_{m1} = g_{m2} = \frac{I_{CQ}}{V_T} = \frac{1.45mA}{26mV} = \underline{55.77 \frac{mA}{V}}$$

# AC (Mid-Frequency) equivalent circuit :-



$$R_B = R_2 \parallel R_3$$

→ Input impedance ( $Z_i^o$ ) :

$$\begin{aligned} Z_i^o &= R_B \parallel V_{II1} = R_2 \parallel R_3 \parallel V_{II1} \\ &= (24K \parallel 12K) \parallel (3.586K) \\ &= 8K \parallel 3.586K \end{aligned}$$

$$Z_i^o = 2.476 K\Omega$$

→ Output impedance ( $Z_o$ ) :

$$Z_o = R_C \parallel R_L = 4.7K \parallel (1K\Omega) = 824.56 \Omega$$

$$\rightarrow A_{v2} = \frac{V_o}{V_{o1}} = \frac{-g_{m2}(R_C \parallel R_L)V_{II2}}{+V_{II2}} = 55.77 \frac{mA}{V} (824.56)$$

$$A_{v2} = 45.98$$

$$\rightarrow A_{v1} = -g_{m1} \left( \frac{V_{II1}}{1+\beta} \right) = 55.77 \times 10^{-3} \left( \frac{3.586K}{201} \right) = -0.9949$$

$$\rightarrow A_{vT} = A_{v1} A_{v2} = 45.98 \times (-0.9949) = -45.75$$