Question 1,

(a) $r_e = 2.5k$, $r_\pi = 350k$, $r_o = 10M$, $g_m = 400 \mu A/V$

(b) $V_{\text{omax}} = 4.3V$, $P_o = 92.45 mW$, $I_{\text{ave}} = 13.67 mA$, efficiency$=67.5\%$

(c) $T_j = 245$ degrees

(d) 3 plots 1) poles in LHP, 2) poles on $j\omega$ axis, 3) poles in RHP.

(e) $g_m = I_c \times I_C$

Question 2,

(a) figure, showing all $v_\pi$’s, labels, etc. CE followed by CC

(b) $v_o = \frac{R_{E2} || R_L}{r_{\pi2} + R_{E2} || R_L}$, $v_{b2} = -g_m \left[ R_{C1} \left( r_{\pi2} + R_{E2} || R_L \right) \left( 1 + \beta_2 \right) \right]$, $\frac{v_{\pi1}}{v_s} = \frac{R_i}{R_s + R || R_L \left( r_{\pi1} \right)}$,

$\frac{v_o}{v_s} = \frac{v_o}{v_{b2} \cdot v_{\pi1}} \frac{v_{\pi1}}{v_s}$

(c) $R_1 || R_2 || r_{\pi1}$

(d) $R_{E2} || r_{o2} || \{ r_{e2} + \left[ r_{\mu2} || r_{o1} \right] R_{C1} \} / (1+\beta)$

(e) $R_{Cin} = R_s + R_1 || R_2 || R_{\pi1}$, $R_{Co} = R_L + R_{E2} || \left[ (r_{\pi2} + R_{C1}) / (1+\beta) \right]$,

$R_{C2} = R_3 \ || \left[ r_{\pi1} + R_1 \ || \ R_2 \ || \ R_S \right] / (1+\beta)$

(f) $C_A = C_{\mu1} \left( 1 - v_{b2} / v_{\pi1} \right)$, and $C_B = C_{\mu1} \left( 1 - v_{\pi1} / v_{b2} \right)$, where $v_{b2} / v_{\pi1}$ is given in 2b,

$\omega_{b1} = \frac{1}{\left( c_{\pi1} + C_A \left( R_s \ || \ R_1 \ || \ R_L \left( 1 + \beta_2 \right) \right) \right)}$, $\omega_{b2} = \frac{1}{\left( C_B + C_{\mu2} \left( R_{C1} \ || \ R_{b2} + R_{E2} || R_L \left( 1 + \beta_2 \right) \right) \right)}$

(g) $R_{C1} = 5k$, $R_{E2} = 2.15k$, $R_1 = 75.45k$, $R_2 = 67K$

Question 3

(a) model – similar to that shown in lab3 notes, p. 35. Important, there are two transistors connecting to $R_L$, $v_x = g_m (1 + g_m [r_e || r_{\pi1}]) R_L \times v_x \times 2 r_{\pi} / \left( R_s + 2 r_{\pi} \right)$, or with standard approximations, small $R_s$, $v_x / v_s = g_m \ R_x$
(ii) \(2r_{\pi}\)

(iii) \(r_{\pi}/2 + R_{\alpha}(1+\beta)\)

(b) pnp mirror with emitter at \(V_{CC}\), \(R_{bias} = 8.6k\), \(V_{min,max} = -4.3, 3.6V\)

(c) \(R = 175\) Ohms, \(V = -1.4V\).

**Question 4,**

4 equations at opamp inputs, simplification, result, \(v_{out}/v_{in} = s^2/[s^2 + s/(CR) + 1/(C^2R^2)]\)

First filter: \(H_0 = 1\), \(\omega_0=1\), \(Q = 0.8\), DC gain, Second Filter: at high frequency, gain = 1, \(\omega_0=100\), gain at \(\omega_0\) is 2. Plots showing LPF followed by HPF (thus dip in between them).

**Question 5**

Loop Gain = \(s/(CR) * K /[s^2 + 3s/(CR) + 1/(C^2R^2)]\) set to 1, solve, \(\omega_0= 1/(CR)\), \(K = 3\).

(b) Gain is reduced by \(1/2\), maximum output voltage is plus and minus 2.7 V.