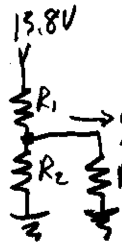
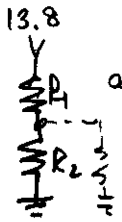
1. A)



$\Rightarrow$

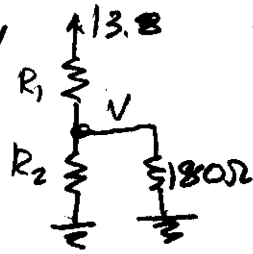


at zero current, $R_L = \infty$, and want there $\Rightarrow 13.8V\left(\frac{R_2}{R_1+R_2}\right) = 5.1V$

(1) Lets go this path: $R_L = \frac{4.5V}{25mA} = \boxed{180\Omega = R_L}$

and for $i < 25mA$, $R_L > 180\Omega$.

Under full load



$V = 13.8\left(\frac{R_2 \| 180}{R_1 + R_2 \| 180}\right) = 4.5V$ (1)

And no load: $13.8\left(\frac{R_2}{R_1+R_2}\right) = 5.1V$ (2)

2 eqns w/ 2 unknowns

Invert them:

$\frac{R_1 + x}{x} = \frac{13.8}{4.5} = 3.07 \rightarrow R_1 + x = 3.07x \rightarrow R_1 = 2.07x = 2.07(R_2 \| 180\Omega)$

$\frac{R_1+R_2}{R_2} = \frac{13.8}{5.1} = 2.71 \rightarrow R_1 + R_2 = 2.71 R_2 \rightarrow R_1 = 1.71 R_2$

(2) $\Rightarrow 1.71 \cancel{R_2} = 2.07\left(\frac{\cancel{R_2} \cdot 180}{R_2 + 180}\right) \rightarrow R_2 + 180 = \frac{2.07}{1.71} \cdot 180 = 218 \rightarrow \boxed{R_2 = 38\Omega}$

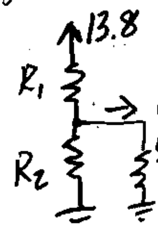
$R_1 = 1.71 R_2 = \boxed{65\Omega = R_1}$

(3) Power: No load, $R_{TOT} = R_1 + R_2 = (38+65)\Omega = 103\Omega$, $P = V^2/R = \frac{13.8^2}{103} = \boxed{1.85W}$ No load

with load $R_{TOT} = R_1 + R_2 \| 180 = 65 + \frac{38 \cdot 180}{38+180} = 96.4\Omega \rightarrow \boxed{P = 1.98W}$ loaded

Efficiency $= \frac{\text{power to load}}{\text{total power}} \cdot 100\% = \frac{(4.5V)^2/180\Omega}{1.98W} = \frac{113mW}{2W} = \boxed{5.6\%}$ efficient

(4) To get $25mA = I_E = h_{fe} \cdot I_B \rightarrow I_B = \frac{25mA}{100} = 250\mu A$. So 2 extremes:



$i = 0 @ V = 5.1 + 0.6 = 5.7V$ (1)

$i = 250\mu A @ V = 4.5 + 0.6 = 5.1V$ (2)

$\rightarrow Z_L = \frac{5.1V}{250\mu A} = \boxed{20.4K\Omega}$

(5)

(1) $13.8\left(\frac{R_2}{R_1+R_2}\right) = 5.7 \rightarrow R_1 + R_2 = \frac{13.8}{5.7} R_2 \rightarrow R_1 = 1.42 R_2$

(2) $13.8\left(\frac{R_2 \| 20.4K}{R_1 + R_2 \| 20.4K}\right) = 5.1 \rightarrow \frac{R_1 + x}{x} = 2.71 \rightarrow R_1 = 1.71 \frac{R_2 \cdot 20.4K}{R_2 + 20.4K} = 1.42 R_2$

$\Rightarrow 24.5K = R_2 + 20.4K \rightarrow \boxed{R_2 = 4.11K\Omega}$ $\boxed{R_1 = 5.83K\Omega}$

(6) No load power $P = V^2/(R_1+R_2) = 13.8^2/(4.11K+5.83K) = \boxed{19.2\,mW}$
What about the transistor? $R_L = \infty \Rightarrow I_e = 0 \Rightarrow I_B = 0 \Rightarrow I_c = 0$...
its turned off.

(7) When $R_L = 180\Omega$, drawing 25mA, 250uA comes from I_B and the rest comes from I_c. We've shown that the base-emitter - $R_L = 180\Omega$ series combination $= 20.4K\Omega \rightarrow$ Power through that part of the circuit is $P = V^2/(R_1 + R_2 \| 20.4K) = 13.8^2/\left(5.83K + \frac{4.11K \cdot 20.4K}{4.11K + 20.4K}\right) = \underline{20.6\,mW}$

But the majority of power comes through I_c: $P = VI = 13.8 \cdot (25mA - 250uA)$
$= \underline{342\,mW}$

So total power $= 363\,mW$
The transistor will dissapate $P = V_{CE} I_c = (13.8 - 4.5)(25mA) = \boxed{233\,mW}$
The load power $= 113\,mW$ (#4) $\Rightarrow$
Efficiency $= \frac{113\,mW}{363\,mW} \cdot 100\% = \boxed{31\%}$, 5.5 times more efficient than the passive circuit