8.1

(a) Since $V_{BE} = 0.8$ V, the BE junction is forward biased.

$V_{CB} = V_{CE} + V_{EB}$

$= 0.4 + (-0.8) = -0.4$ V

Thus, the CB junction is forward biased.

Therefore, the transistor is in the saturation region.

(b)

$V_{BE} = V_{BC} + V_{CE}$

$= -1.4 + 2.1 = 0.7$ V

The EB junction is forward biased.

$V_{CB} = 1.4$ V, the CB junction is reverse biased.

Therefore, the transistor is in the active region.

(c) $V_{CB} = 0.9$ V for a *pnp* transistor implies that the CB junction is forward biased.

$V_{BE} = V_{BC} - V_{CE}$

$= -0.9 - 0.4 = -1.3$ V

The BE junction is forward biased.

Therefore, the transistor is in the saturation region.

(d) With $V_{BE} = -1.2$ V, the BE junction is reverse biased. $V_{CB} = 0.6$: the CB junction is reverse biased. Therefore, the transistor is in the cut-off region.

8.3

(a) $I_E = I_C + I_B = 1\text{ mA} + 20\mu A = 1.02\text{ mA}$

$V_E = 1000\, I_E = 1.02\text{ V}$

$V_{RC} = 5000\, I_C = 5\text{ V}$

$V_{CB} = 20 - V_{RC} - V_{BE} - V_E$

$= 20 - 5 - 0.7 - 1.02 = 13.28\text{ V}$

The CB junction is reverse-biased.

Therefore, the transistor is operating in the active region.

(b) $I_E = 3.2\text{ mA} + 0.3\text{ mA} = 3.5\text{ mA}$

$V_E = 3.5\text{ V}$

$V_{RC} = 16\text{ V}$

$V_{CB} = 20 - 16 - 0.8 - 3.5 = -30\text{ mV}$

The CB junction is forward-biased.

Therefore, the transistor is operating in the saturation region.

(c) $I_E = 3\text{ mA} + 1.5\text{ mA} = 4.5\text{ mA}$

$V_E = 4.5\text{ V}$

$V_{RC} = 22.5\text{ V}$

$V_{CB} = 20 - 22.5 - 0.85 - 4.5 = -7.85\text{ V}$

The CB junction is forward-biased.

Therefore, the transistor is operating in the saturation region.

8.4

(a) In the pnp transistor, $V_{BE} = -0.6\text{ V}$:

the EB junction is forward biased.

$V_{CB} = V_{CE} - V_{BE}$

$= -4 + 0.6 = -3.4\text{ V}$

The CB junction is reverse biased.

Therefore, the transistor is in the active region.

(b) For the npn transistor, $V_{CB} = 0.7\text{ V}$;

the CB junction is reverse biased.

$V_{BE} = V_{BC} + V_{CE}$

$= -0.7 + 0.2 = -0.5\text{ V}$

The BE junction is reverse biased.

Therefore, the transistor is in cut-off region.

(c) For the npn transistor, $V_{BE} = 0.7\text{ V}$:

the BE junction is forward biased.

$V_{BC} = V_{BE} - V_{CE} = 0.7 - 0.3 = 0.4\text{ V}$

The CB junction is forward biased.

Therefore, the transistor is in the saturation region.

(d) In the pnp transistor, $V_{CB} = -0.6\text{ V}$:

the CB junction is reverse biased.

$V_{BE} = V_{BC} + V_{CE}$

$= 0.6 - 5.4 = -4.8\text{ V}$

The EB junction is forward biased.

Therefore, the transistor is in the active region.

8.5

$V_{BE} = 0.6V$ and the BE junction is forward biased.

$$I_B = \frac{V_{CC} - V_{BE}}{R_1} = \frac{12 - 0.6}{820k} = 13.9\mu A$$

$$I_C = \beta I_B = 1.39mA$$

Writing KVL around the right-hand side of the circuit:

$$-V_{CC} + I_C R_C + V_{CE} + I_E R_E = 0$$

$$V_{CE} = V_{CC} - I_C R_C - (I_B + I_C)R_E$$
$$= 12 - (1.39mA)(2.2k\Omega) - (1.39 + 0.0139)mA(910\Omega)$$
$$= 7.664V$$

$$V_{BC} = V_{BE} + V_{CE} = 0.6 + 7.664 = 8.264V$$

$V_{CE} > V_{BE} \Rightarrow$ active region

8.16

(a) From KVL:

$$-30 + I_{B1}(750k\Omega) + V_{BE1} = 0$$

$$I_{B1} = \frac{30 - 0.7}{750k} = 39.07\mu A$$

$$I_{C1} = \beta I_{B1} = 3.907mA$$

$$V_{C1} = 30 - (3.907mA)(6.2k\Omega) = 5.779V$$

$$V_{CE1} = V_{C1} = 5.779V$$

(b) Again, from KVL:

$$-5.779 + V_{BE2} + I_{E2}(4.7k\Omega) = 0$$

$$I_{E2} = \frac{5.779 - 0.7}{4.7k} = 1.081mA$$

$$I_{C2} = I_{E2}\left(\frac{\beta}{\beta + 1}\right) = 1.081mA\left(\frac{100}{101}\right) = 1.07mA$$

Also,

$$-30 + I_{C2}(20k + 4.7k) + V_{CE2} = 0$$

$$V_{CE2} = 30 - (1.07mA)(20k + 4.7k) = 3.574V$$

And,

$$I_{C2} = \frac{30 - V_{C2}}{20k}$$

$$\Rightarrow V_{C2} = 30 - (1.07m)(20k) = 8.603V$$

8.9

Applying KVL to the right-hand side of the circuit,

$$-V_{CC} + I_E R_E + V_{EB} = 0$$

$$I_E = \frac{V_{CC} - V_{EB}}{R_E} = \frac{20 - 0.6}{39k} = 497.4\mu A$$

Since $\beta >> 1$, $I_C \approx I_E = 497.4\mu A$

Applying KVL to the left-hand side:

$$V_{CB} + I_C R_C - V_{DD} = 0$$

$$V_{CB} = V_{DD} - I_C R_C$$
$$= 20V - (497.4\mu A)(20k\Omega)$$
$$= 10.05V$$

8.20

Assume $V_{CEsat} = 0.2$ V, the current I_C can be found as

$$I_C = \frac{V_{CC} - V_{CEsat}}{R_C} = 4.8 \text{ mA}$$

Therefore, $I_B = \dfrac{I_C}{\beta} = 0.096 \text{ mA} = 96 \ \mu A$

Assuming $V_\gamma = V_{BEsat} = 0.6$ V, we have

$$V_{BB} = I_B R_B + V_{BEsat} = 1.56 \text{ V}$$

That is $V_{BB} > 1.56$ V