1. What names are applied to the two types of BJT transistors? Sketch the basic construction of each and label the various minority and majority carriers in each. Draw the graphic symbol next to each. Is any of this information altered by changing from a silicon to a germanium base?

2. What is the major difference between a bipolar and a unipolar device?
Ans:
A bipolar transistor utilizes holes and electrons in the injection or charge flow process, while unipolar devices utilize either electrons or holes, but not both, in the charge flow process.

3. How must the two transistor junctions be biased for proper transistor amplifier operation?
Ans:
Forward- and reverse-biased.

4. What is the source of the leakage current in a transistor?
Ans:
The leakage current I_{CO} is the minority carrier current in the collector.

5. Sketch a figure for the forward-biased junction of an *npn* transistor.
Describe the resulting carrier motion.

6. Sketch a figure for the reverse-biased junction of an *npn* transistor. Describe the resulting carrier motion.

7. Sketch a figure for the majority- and minority-carrier flow of an *npn* transistor.
Describe the resulting carrier motion.

8. Which of the transistor currents is always the largest? Which is always the smallest? Which two currents are relatively close in magnitude?

Ans:
I_E the largest
I_B the smallest
$I_C \cong I_E$

9. For a common base amplifier, If the emitter current of a transistor is 8 mA and I_B is 1/100 of I_C, determine the levels of I_C and I_B.

Ans:

$$I_B = \frac{1}{100} I_C \Rightarrow I_C = 100 I_B$$
$$I_E = I_C + I_B = 100 I_B + I_B = 101 I_B$$
$$I_B = \frac{I_E}{101} = \frac{8 \text{ mA}}{101} = \mathbf{79.21\ \mu A}$$
$$I_C = 100 I_B = 100(79.21\ \mu\text{A}) = \mathbf{7.921\ mA}$$

10. For a common base amplifier,
a. Using the characteristics of Figs. 3.7 and 3.8 (Below) , determine I_C if V_{CB} = 5 V and V_{BE} = 0.7 V.
ANS: 2 mA

b. Determine V_{BE} if I_C = 5 mA and V_{CB} =15 V
ANS: ~0.78 V.

c. Repeat part (b) using the characteristics of Fig. 3.10b .
ANS: ~0.8 V.

d. Repeat part (b) using the characteristics of Fig. 3.10c .
ANS: 0.7 V.

e. Compare the solutions for V_{BE} for parts (b) through (d).
Can the difference be ignored if voltage levels greater than a few volts are typically encountered?

11. **a.** Given an α_{dc} of 0.998, determine I_C if I_E = 4 mA.
b. Determine α_{dc} if I_E = 2.8 mA, I_C = 2.75 mA and I_{CBO} = 0.1 mA.

(a) $I_C = \alpha I_E = (0.998)(4 \text{ mA}) = \mathbf{3.992 \text{ mA}}$

(b) $I_E = I_C + I_B \Rightarrow I_C = I_E - I_B = 2.8 \text{ mA} - 0.02 \text{ mA} = \mathbf{2.78 \text{ mA}}$

$$\alpha_{dc} = \frac{I_C}{I_E} = \frac{2.78 \text{ mA}}{2.8 \text{ mA}} = \mathbf{0.993}$$

12. From memory only, sketch the common-base BJT transistor configuration (for *npn* and *pnp*) and indicate the polarity of the applied bias and resulting current directions.

13. **a.** For the common-emitter characteristics of Fig. 3.13 , find the dc beta at an operating point of V_{CE} = 6 V and I_C = 2 mA.
b. Find the value of a corresponding to this operating point.
c. At V_{CE} = 6 V, find the corresponding value of I_{CEO} .
d. Calculate the approximate value of I_{CBO} using the dc beta value obtained in part (a).

(a) $$\beta_{dc} = \frac{I_C}{I_B} = \frac{2 \text{ mA}}{18 \ \mu\text{A}} = \mathbf{111.11}$$

(b) $$\alpha = \frac{\beta}{\beta+1} = \frac{111.11}{111.11+1} = \mathbf{0.991}$$

(c) $I_{CEO} = \mathbf{0.3 \text{ mA}}$

(d) $$\begin{aligned} I_{CBO} &= (1-\alpha)I_{CEO} \\ &= (1-0.991)(0.3 \text{ mA}) = \mathbf{2.7 \ \mu A} \end{aligned}$$

14. **a.** Using the characteristics of Fig. 3.13a , determine I_{CEO} at V_{CE} = 10 V.
b. Determine β_{dc} at I_B = 10 mA and V_{CE} = 10 V.
c. Using the β_{dc} determined in part (b), calculate I_{CBO} .

(a) Fig. 3.14(a): $I_{CEO} \cong \mathbf{0.3 \text{ mA}}$

(b) Fig. 3.14(a): $I_C \cong 1.35$ mA

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{1.35 \text{ mA}}{10 \ \mu\text{A}} = \mathbf{135}$$

(c) $$\alpha = \frac{\beta}{\beta+1} = \frac{135}{136} = \mathbf{0.9926}$$

$$\begin{aligned} I_{CBO} &\cong (1-\alpha)I_{CEO} \\ &= (1-0.9926)(0.3 \text{ mA}) \\ &= \mathbf{2.2 \ \mu A} \end{aligned}$$

15. **a.** Given that α_{dc} = 0.980, determine the corresponding value of β_{dc} .
b. Given β_{dc} = 120, determine the corresponding value of a.

c. Given that β_{dc} = 120 and I_C = 2.0 mA, find I_E and I_B .

$$\text{(a)}\quad \beta = \frac{\alpha}{1-\alpha} = \frac{0.980}{1-0.980} = \mathbf{49}$$

$$\text{(b)}\quad \alpha = \frac{\beta}{\beta+1} = \frac{120}{120+1} = \mathbf{0.992}$$

$$\text{(c)}\quad I_B = \frac{I_C}{\beta} = \frac{2\text{ mA}}{120} = \mathbf{16.66\ \mu A}$$

$$I_E = I_C + I_B = 2\text{ mA} + 16.66\ \mu\text{A} \cong \mathbf{2.017\ mA}$$

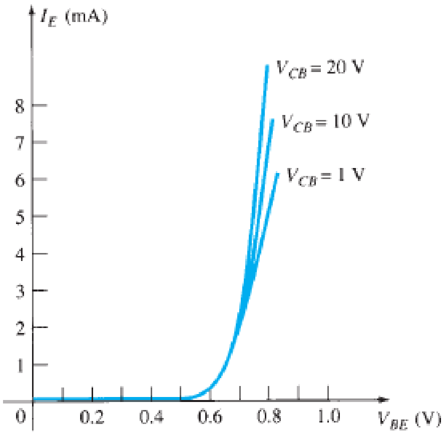

FIG. 3.7

Input or driving point characteristics for a common-base silicon transistor amplifier.

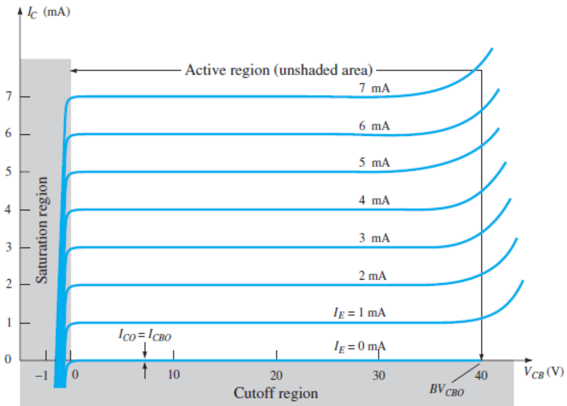

FIG. 3.8

Output or collector characteristics for a common-base transistor amplifier.

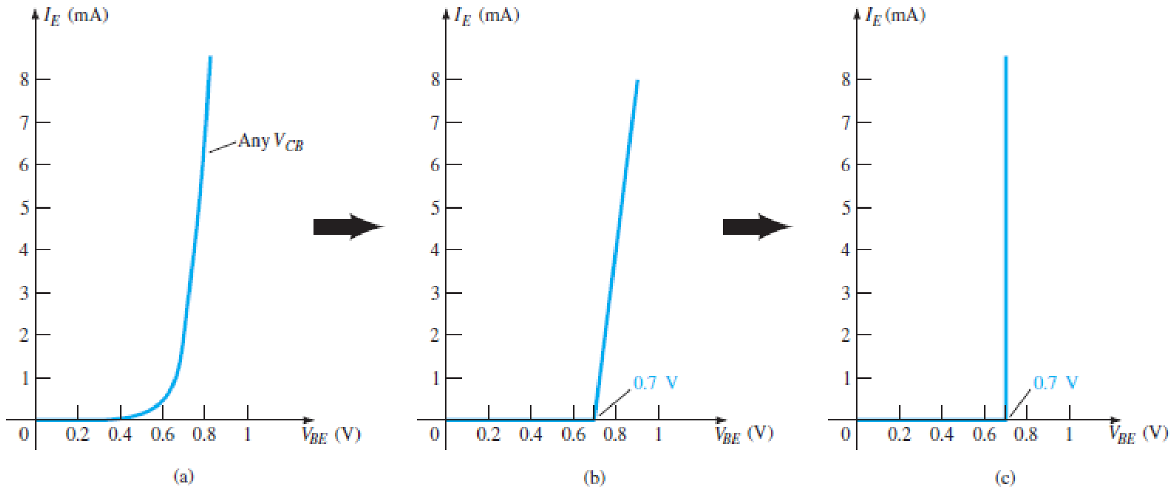

FIG. 3.10

Developing the equivalent model to be employed for the base-to-emitter region of an amplifier in the dc mode.

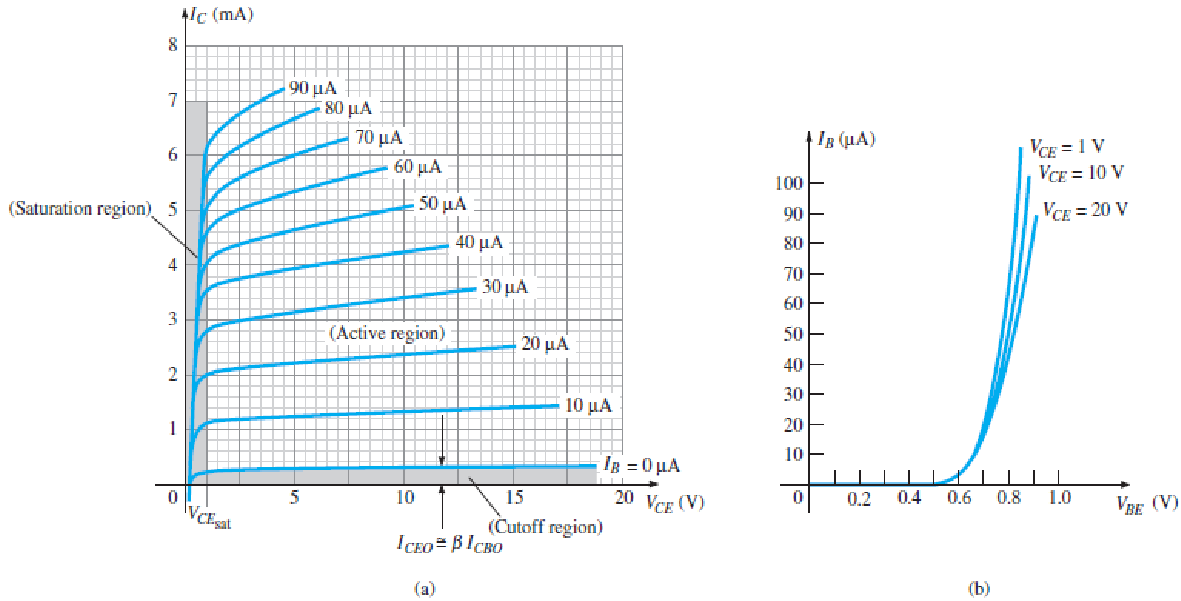

FIG. 3.13

Characteristics of a silicon transistor in the common-emitter configuration: (a) collector characteristics; (b) base characteristics.