The voltage between the emitter and ground is called the *emitter voltage.* It equals:

$$V_E = 5\text{ V} - 0.7\text{ V} = 4.3\text{ V}$$

This voltage is across the emitter resistance, so we can use Ohm's law to find the emitter current:

$$I_E = \frac{4.3\text{ V}}{2.2\text{ k}\Omega} = 1.95\text{ mA}$$

This means that the collector current is 1.95 mA to a close approximation. When this collector current flows through the collector resistor, it produces a voltage drop of 1.95 V. Subtracting this from the collector supply voltage gives the voltage between the collector and ground:

$$V_C = 15\text{ V} - (1.95\text{ mA})(1\text{ k}\Omega) = 13.1\text{ V}$$

From now on, we will refer to this collector-to-ground voltage as the *collector voltage.*

This is the voltage a troubleshooter would measure when testing a transistor circuit. One lead of the voltmeter would be connected to the collector, and the other lead would be connected to ground. If you want the collector-emitter voltage, you have to subtract the emitter voltage from the collector voltage as follows:

$$V_{CE} = 13.1\text{ V} - 4.3\text{ V} = 8.8\text{ V}$$

So, the emitter-biased circuit of Fig. 7-10 has a Q point with these coordinates: $I_C = 1.95$ mA and $V_{CE} = 8.8$ V.

The collector-emitter voltage is the voltage used for drawing load lines and for reading transistor data sheets. As a formula:

$$\mathbf{V_{CE} = V_C - V_E} \tag{7-8}$$

GOOD TO KNOW

Because the values of I_C and V_{CE} are not affected by the value of beta in an emitter-biased circuit, this type of circuit is said to be *beta-independent.*

Circuit Is Immune to Changes in Current Gain

Here is why emitter bias excels. The Q point of an emitter-biased circuit is immune to changes in current gain. The proof lies in the process used to analyze the circuit. Here are the steps we used earlier:

1. Get the emitter voltage.
2. Calculate the emitter current.
3. Find the collector voltage.
4. Subtract the emitter from the collector voltage to get V_{CE}.

At no time do we need to use the current gain in the foregoing process. Since we don't use it to find the emitter current, collector current, and so on, the exact value of current gain no longer matters.

By moving the resistor from the base to the emitter circuit, we force the base-to-ground voltage to equal the base supply voltage. Before, almost all this supply voltage was across the base resistor, setting up a *fixed base current.* Now, all this supply voltage minus 0.7 V is across the emitter resistor, setting up a *fixed emitter current.*

Minor Effect of Current Gain

The current gain has a minor effect on the collector current. Under all operating conditions, the three currents are related by:

$$I_E = I_C + I_B$$

which can be rearranged as:

$$I_E = I_C + \frac{I_C}{\beta_{dc}}$$

Solve this for the collector current, and you get:

$$\mathbf{I_C = \frac{\beta_{dc}}{\beta_{dc} + 1} I_E} \tag{7-9}$$

The quantity that multiplies I_E is called a **correction factor.** It tells you how I_C differs from I_E. When the current gain is 100, the correction factor is:

$$\frac{\beta_{dc}}{\beta_{dc} + 1} = \frac{100}{100 + 1} = 0.99$$

This means that the collector current is equal to 99 percent of the emitter current. Therefore, we get only a 1 percent error when we ignore the correction factor and say that the collector current equals the emitter current.

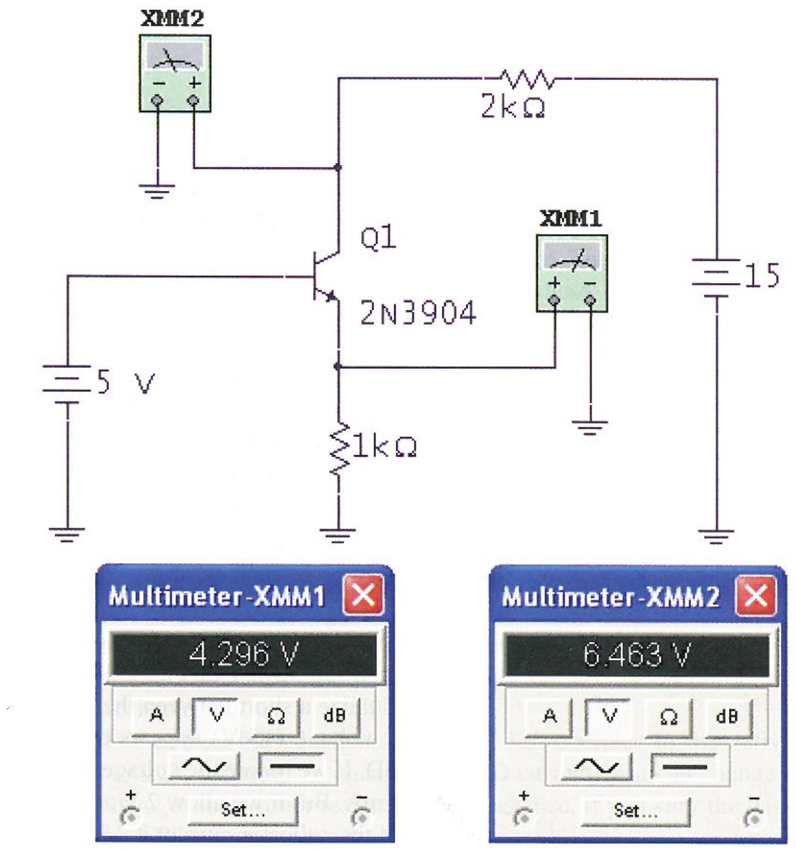
Example 7-9 MultiSim

What is the voltage between the collector and ground in the MultiSim Fig. 7-11? Between the collector and the emitter?

SOLUTION The base voltage is 5 V. The emitter voltage is 0.7 V less than this, or:

$$V_E = 5\text{ V} - 0.7\text{ V} = 4.3\text{ V}$$

MultiSim **Figure 7-11** Meter Values.



Multimeter-XMM1
4.296 V

Multimeter-XMM2
6.463 V