Kazmerski, L., and S. Wagner (1985). *Current Topics in Photovoltaics*, T. J. Coutts and J. D. Meakin (eds.), Academic Press, London, p. 41.

Kuehn, T. H., J. W. Ramsey, and J. L. Threlkeld (1998). *Thermal Environmental Engineering*, 3rd ed., Prentice-Hall, Englewood Cliffs, NJ.

Maycock, P. (2004). The State of the PV Market, *Solar Today*, Jan/Feb pp 32–35.

Schmela, M. (2000). Do You Remember S-Web?, *Photon International, The Photovoltaic Magazine*, September.

SERI (1985). *Photovoltaics Technical Information Guide*, Solar Energy Research Institute, SERI/SP-271-2452, U.S. Department of Energy, Washington, D.C.

PROBLEMS

8.1 For the following materials, determine the maximum wavelength of solar energy capable of creating hole-electron pairs:

a. Gallium arsenide, GaAs, band gap 1.42 eV.

b. Copper indium diselenide, $CuInSe_2$, band gap 1.01 eV

c. Cadmium sulfide, CdS, band gap 2.42 eV.

8.2 A *p-n* junction diode at 25°C carries a current of 100 mA when the diode voltage is 0.5 V. What is the reverse saturation current, I_0?

8.3 For the simple equivalent circuit for a 0.005 m^2 photovoltaic cell shown below, the reverse saturation current is $I_0 = 10^{-9}$ A and at an insolation of 1-sun the short-circuit current is $I_{SC} = 1$ A,. At 25°C, find the following:

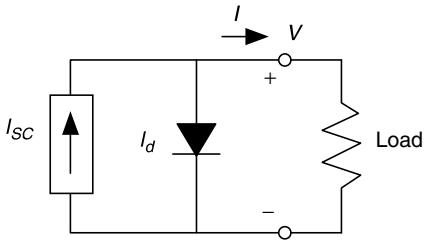

Figure P8.3

a. The open-circuit voltage.

b. The load current when the output voltage is $V = 0.5$ V.

c. The power delivered to the load when the output voltage is 0.5 V.

d. The efficiency of the cell at $V = 0.5$ V.

8.4 The equivalent circuit for a PV cell includes a parallel resistance of $R_P = 10\ \Omega$. The cell has area 0.005 m^2, reverse saturation current of $I_0 = 10^{-9}$ A and at an insolation of 1-sun the short-circuit current is $I_{SC} = 1$ A, At 25°C, with an output voltage of 0.5 V, find the following:

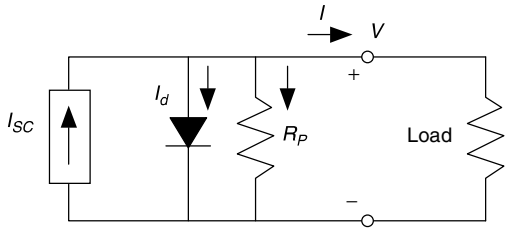

Figure P8.4

a. The load current.

b. The power delivered to the load.

c. The efficiency of the cell.

8.5 The following figure shows two I-V curves. One is for a PV cell with an equivalent circuit having an infinite parallel resistance (and no series resistance). What is the parallel resistance in the equivalent circuit of the other cell?

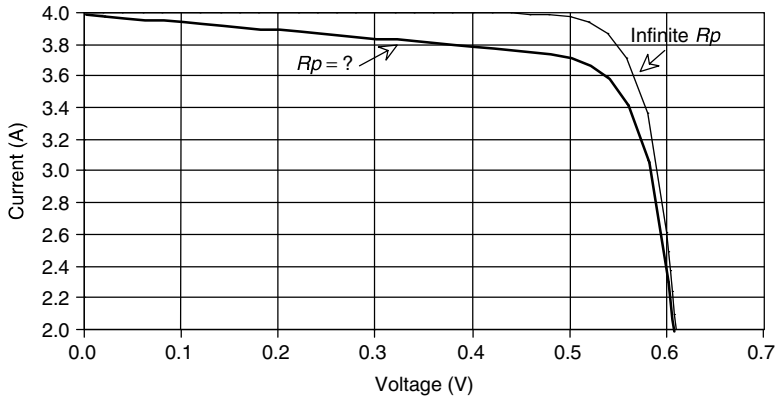

Figure P8.5

8.6 The following figure shows two I-V curves. One is for a PV cell with an equivalent circuit having no series resistance (and infinite parallel resistance). What is the series resistance in the equivalent circuit of the other cell?

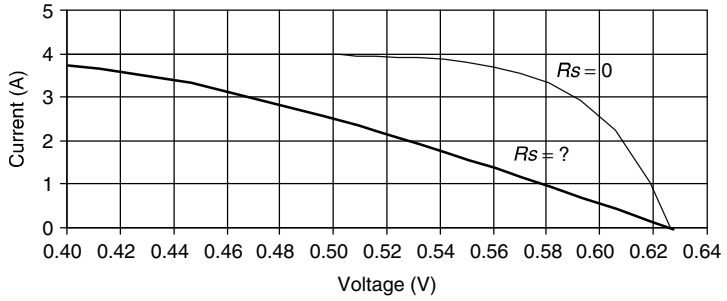

Figure P8.6

8.7 Estimate the cell temperature and power delivered by a 100-W PV module with the following conditions. Assume 0.5%/°C power loss.

a. NOCT = 50°C, ambient temperature of 25°C, insolation of 1-sun.

b. NOCT = 45°C, ambient temperature of 0°C, insolation of 500 W/m^2.

c. NOCT = 45°C, ambient temperature of 30°C, insolation of 800 W/m^2.

8.8 A module with 40 cells has an idealized, rectangular I-V curve with I_{SC} = 4 A and V_{OC} = 20 V. If a single cell has a parallel resistance of 5 Ω and negligible series resistance, draw the I-V curve if one cell is completely shaded. What current would it deliver to a 12-V battery (vertical I-V load at 12 V)?

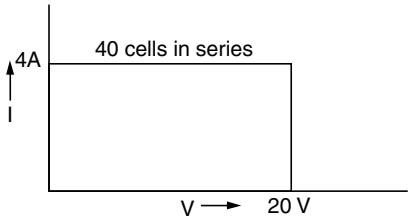

Figure P8.8

8.9 Suppose a PV module has the 1-sun I-V curve shown below. Within the module itself, the manufacturer has provided a pair of bypass diodes to help the panel deliver some power even when many of the cells are shaded. Each diode bypasses half of the cells, as shown. You may consider the diodes to be "ideal;" that is, they have no voltage drop across them when conducting.

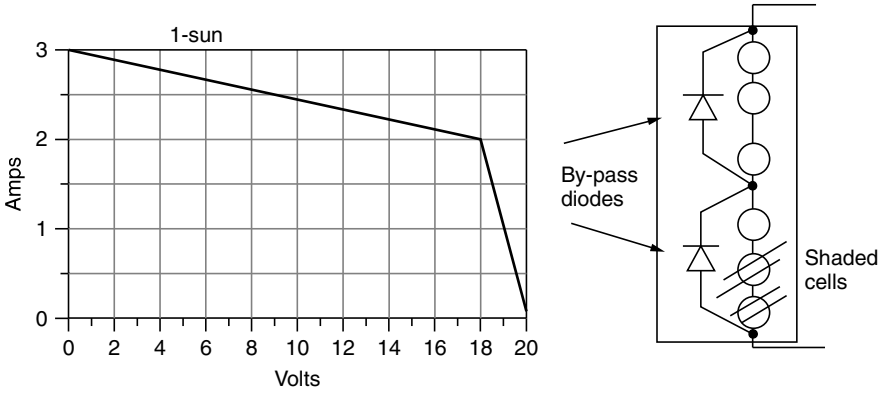

Figure P8.9

Suppose there is enough shading on the bottom cells to cause the lower diode to start conducting. Draw the new "shaded" I-V curve for the module.