

406.

**Problem 33.13 (RHK)**

*A solar cell generates a potential difference of 0.10 V when a 500- $\Omega$  resistance is connected across it and a potential difference of 0.16 V when a 1000- $\Omega$  resistance is substituted. We have to find (a) the internal resistance and (b) the emf of the solar cell. (c) The area of the cell is 5.0 cm<sup>2</sup> and the intensity of light striking it is 2.0 mW cm<sup>-2</sup>. We have to find the efficiency of the cell for converting light energy to internal energy in the 1000- $\Omega$  external resistor.*



**Solution:**

(a)

Let the emf of the solar cell be  $E$  V and its internal resistance be  $r$   $\Omega$ . The solar cell generates a potential difference of 0.10 V when a 500- $\Omega$  resistor is connected across it. From Ohm's law, we have

$$\frac{E \times 500 \Omega}{500 \Omega + r} \text{ V} = 0.10 \text{ V.}$$

The other data is that it generates a potential difference of 0.16 V when a 1000- $\Omega$  resistance is connected across it. Using this data we write the second equation for determining the values of E and  $r$ . It is

$$\frac{E \times 1000 \Omega}{1000 \Omega + r} V = 0.16 V.$$

By dividing the two equations we get a linear equation, which can be solved for  $r$ . It is

$$\frac{500 \Omega + r}{1000 \Omega + r} \times \frac{1000}{500} = \frac{0.16}{0.10},$$

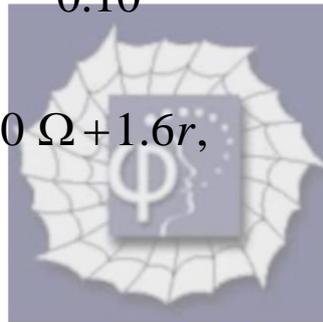
or

$$1000 \Omega + 2r = 1600 \Omega + 1.6r,$$

or

$$0.4r = 600 \Omega,$$

$$\therefore r = 1500 \Omega.$$



(b)

The emf of the solar cell is

$$E = \frac{0.1 \times (500 + 1500)}{500} V = 0.4 V.$$

It is given that the area of the cell is 5.0 cm<sup>2</sup> and the intensity of light striking it is 2.0 mW cm<sup>-2</sup>.

(c)

We will next find the efficiency of the cell for converting light energy to internal energy in the 1000- $\Omega$  external

resistor. Current flowing through the 1000- $\Omega$  resistor connected to the solar cell is

$$i = \frac{0.4 \text{ V}}{(1000 + 1500) \Omega} = 0.16 \times 10^{-3} \text{ A.}$$

Joule heat in the 1000- $\Omega$  resistor will be

$$P = i^2 R = (0.16 \times 10^{-3})^2 \times 1000 \text{ W} = 2.56 \times 10^{-5} \text{ W.}$$

Light energy absorbed by the cell per second is

$$U = \text{area of the cell} \times \text{intensity of light} = 5.0 \times 2.0 \times 10^{-3} \text{ W} \\ = 10.0 \times 10^{-3} \text{ W.}$$

Therefore, the percentage efficiency of the solar cell for converting light energy into internal energy is

$$e = \frac{2.56 \times 10^{-5}}{10 \times 10^{-3}} \times 100 = 0.256\%.$$

