EXAMPLE 3.10

Substituting for R_1, we have a

$$V_1 = \frac{2V}{2\left(\dfrac{R_0 \times R}{R_0 + 2R}\right) + R_0} \times \frac{R_0 \times R}{R_0 + 2R}$$

$$V_1 = \frac{2VR}{2R + R_0 + 2R}$$

or $\quad V_1 = \frac{2VR}{R_0 + 4R}$.

SUMMARY

1. *Current* through a given area of a conductor is the net charge passing per unit time through the area.

2. To maintain a steady current, we must have a closed circuit in which an external agency moves electric charge from lower to higher potential energy. The work done per unit charge by the source in taking the charge from lower to higher potential energy (i.e., from one terminal of the source to the other) is called the electromotive force, or *emf*, of the source. Note that the emf is not a force; it is the voltage difference between the two terminals of a source in open circuit.

3. *Ohm's law*: The electric current I flowing through a substance is proportional to the voltage V across its ends, i.e., $V \propto I$ or $V = RI$, where R is called the *resistance* of the substance. The unit of resistance is ohm: $1\,\Omega = 1$ V A^{-1}.

4. The *resistance* R of a conductor depends on its length l and cross-sectional area A through the relation,

$$R = \frac{\rho l}{A}$$

where ρ, called *resistivity* is a property of the material and depends on temperature and pressure.

5. *Electrical resistivity* of substances varies over a very wide range. Metals have low resistivity, in the range of 10^{-8} Ω m to 10^{-6} Ω m. Insulators like glass and rubber have 10^{22} to 10^{24} times greater resistivity. Semiconductors like Si and Ge lie roughly in the middle range of resistivity on a logarithmic scale.

6. In most substances, the carriers of current are electrons; in some cases, for example, ionic crystals and electrolytic liquids, positive and negative ions carry the electric current.

7. *Current density* $\mathbf{j}$ gives the amount of charge flowing per second per unit area normal to the flow,

$\mathbf{j} = nq\,\mathbf{v}_{\mathrm{d}}$

where n is the number density (number per unit volume) of charge carriers each of charge q, and $\mathbf{v}_{\mathrm{d}}$ is the *drift velocity* of the charge carriers. For electrons $q = -e$. If $\mathbf{j}$ is normal to a cross-sectional area $\mathbf{A}$ and is constant over the area, the magnitude of the current I through the area is $nev_{\mathrm{d}}\,A$.

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