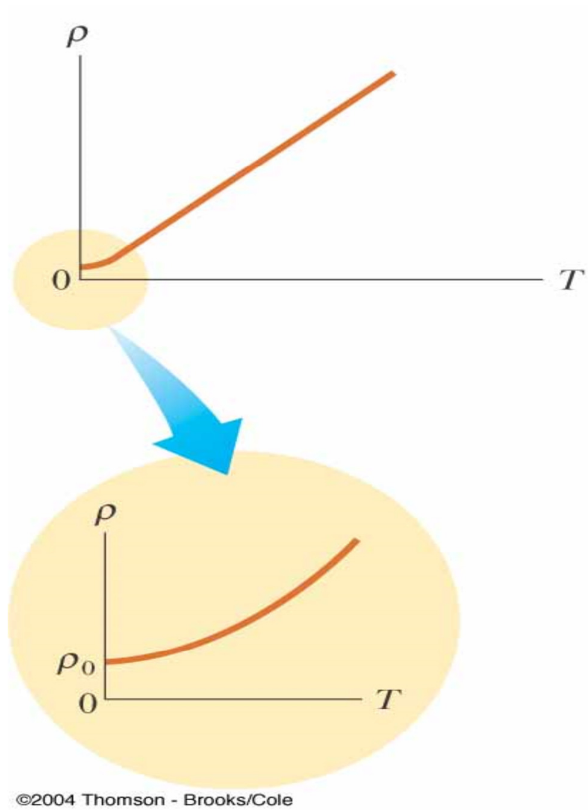
27-4 **Resistance and Temperature**

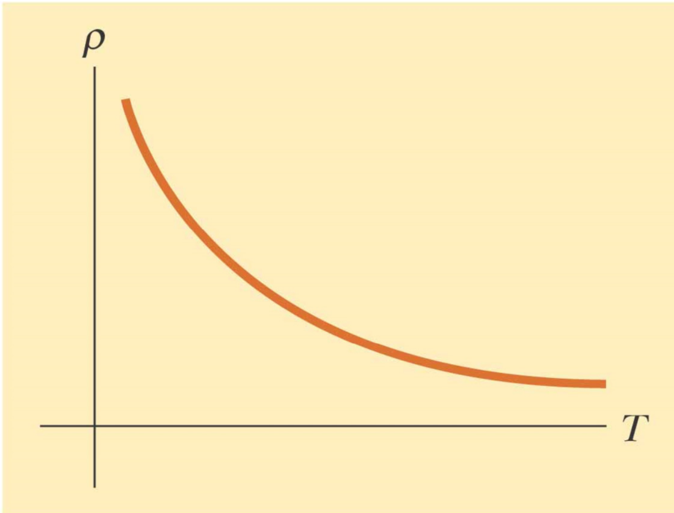
Over a limited temperature range, the resistivity of a metal varies approximately linearly with temperature as can be seen in the figure below and according to the expression:



$$\rho = \rho_0[1+\alpha(T-T_0)] \qquad (27\text{-}8)$$

where is the resistivity at some temperature *T (in degrees Celsius),* ρ_0 *is the resistivity* at some reference temperature T_0 *(usually taken to be 20°C), and* ρ *is the* temperature coefficient of resistivity.

Please note that for some material (for example, semiconductor) the sign of α is negative. The relation between the resistivity and T in this material is shown in the figure below where one can note that the resistivity decreases with temperature.



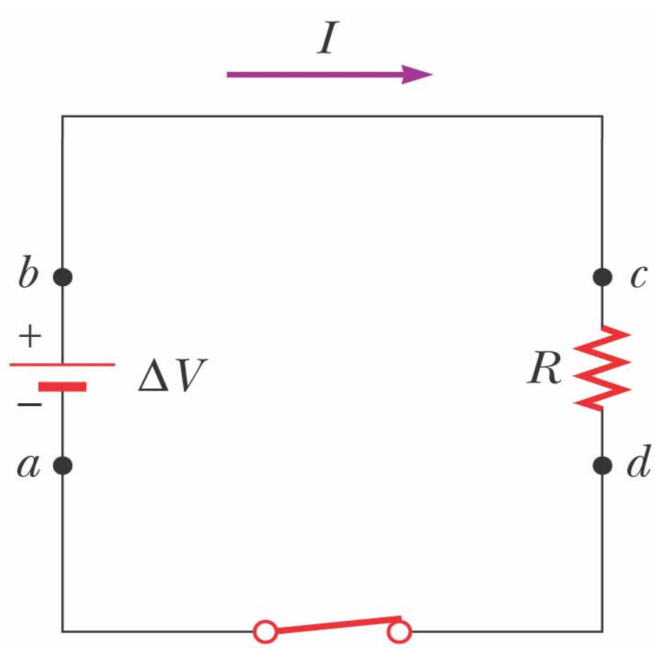
Because resistance is proportional to resistivity (Eq. 27-6), we can write the variation of resistance as,

$$R = R_0[1+\alpha(T-T_0)] \qquad (27\text{-}9)$$

Example 27-4:

Nichrome wire has $\alpha = 0.4\text{x}10^{-3}/°\text{C}$, it is initially at 20 °C. Calculate the temperature at which its resistance is doubled.

27-6 Electric energy and power



If a battery is used to establish an electric current in a conductor, the chemical energy stored in the battery is continuously transformed into kinetic energy of the charge carriers.

In the conductor, this kinetic energy is quickly lost as a result of collisions between the charge carriers and the atoms making up the conductor, and his leads to an increase in the temperature of the conductor. In other words, the chemical energy stored in the battery is continuously transformed to internal energy associated with the temperature of the conductor.

Now imagine following a positive quantity of charge *Q that is* moving clockwise around the circuit (shown up) from point *a through the battery and resistor* back to point *a.*

As the charge moves from a to b through the battery, its electric potential energy U increases by an amount ($\Delta V.\Delta Q$) (where ΔV is the potential difference between b and a), while the chemical potential energy in the battery decreases by the same amount. (Recall that $\Delta U = q. \Delta V$).

However, as the charge moves from c to d through the resistor, it loses this electric potential energy as it collides with atoms in the resistor, thereby producing internal energy. **If we neglect the resistance of the connecting wires**, no loss in energy occurs for paths bc and da. When the charge arrives at point a, it must have the same electric potential energy (zero) that it had at the start.

Note that because charge cannot build up at any point, the current is the same everywhere in the circuit.

The rate at which the charge *Q loses potential energy in going through the* resistor is

$$\frac{dU}{dt} = \frac{d}{dt}(q.\Delta \text{v}) = \frac{dq}{dt}\Delta \text{v} = \text{I}.\Delta \text{v} \qquad (27\text{-}9)$$

where *I is the current in the circuit. In contrast, the charge regains this energy* when it passes through the battery.

Because the rate at which the charge loses energy equals the power delivered to the resistor (which appears as internal energy), we have

$$P = \text{I}.\Delta \text{v} = \text{I}^2.R = \frac{(\Delta \text{v})^2}{R} \qquad (27\text{-}9)$$

Example 27-7

An electric heater is constructed by applying a potential difference of 120 V to a Ni-chrome wire that has a total resistance of 8.0 Ω . Find the current carried by the wire and the power rating of the heater.

Example 27-9

Estimate the cost of cooking a turkey for 4 h in an oven that operates continuously at 20.0 A and 240 V.