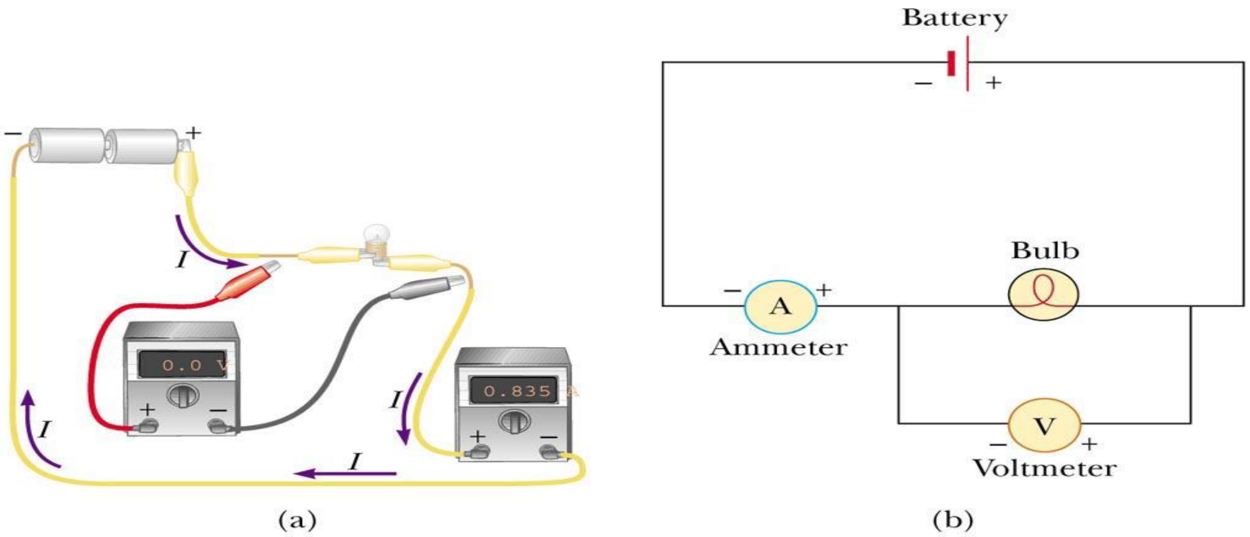
Chapter 5

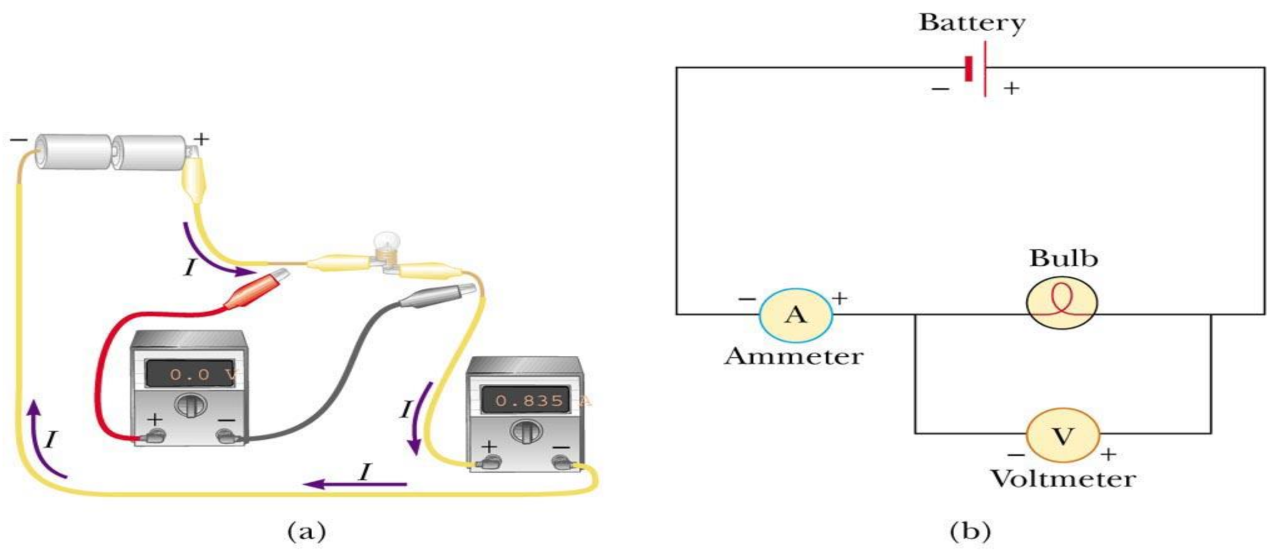
Resistance

Meters in a Circuit – Ammeter



- An ammeter is used to measure current
  - In line with the bulb, all the charge passing through the bulb also must pass through the meter

Meters in a Circuit – Voltmeter



- A voltmeter is used to measure voltage (potential difference)
  - Connects to the two ends of the bulb

Resistance

- In a conductor, the voltage applied across the ends of the conductor is proportional to the current through the conductor
- The constant of proportionality is the *resistance* of the conductor

$$R \equiv \frac{\Delta V}{I}$$

Resistance, cont

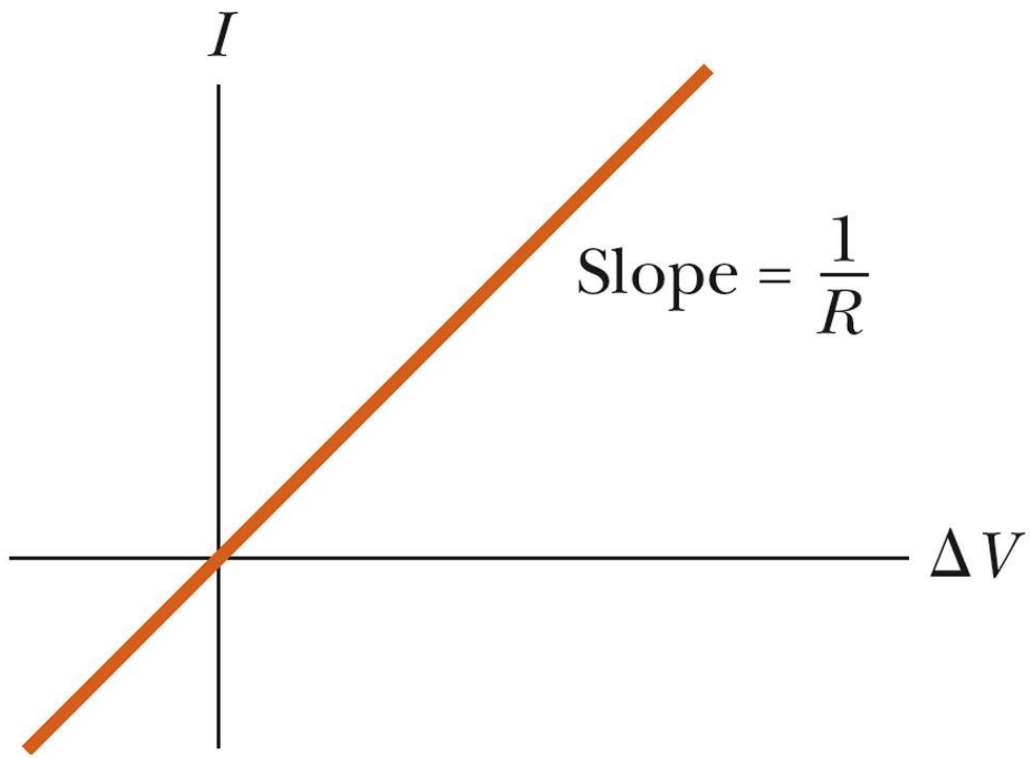
- Units of resistance are *ohms* (Ω)
  - $1\ \Omega = 1\ V / A$
- Resistance in a circuit arises due to collisions between the electrons carrying the current with the fixed atoms inside the conductor

Ohm’s Law

- Experiments show that for many materials, including most metals, the resistance remains constant over a wide range of applied voltages or currents
- This statement has become known as *Ohm’s Law*
  - $\Delta V = I R$
- Ohm’s Law is an empirical relationship that is valid only for certain materials
  - Materials that obey Ohm’s Law are said to be *ohmic*

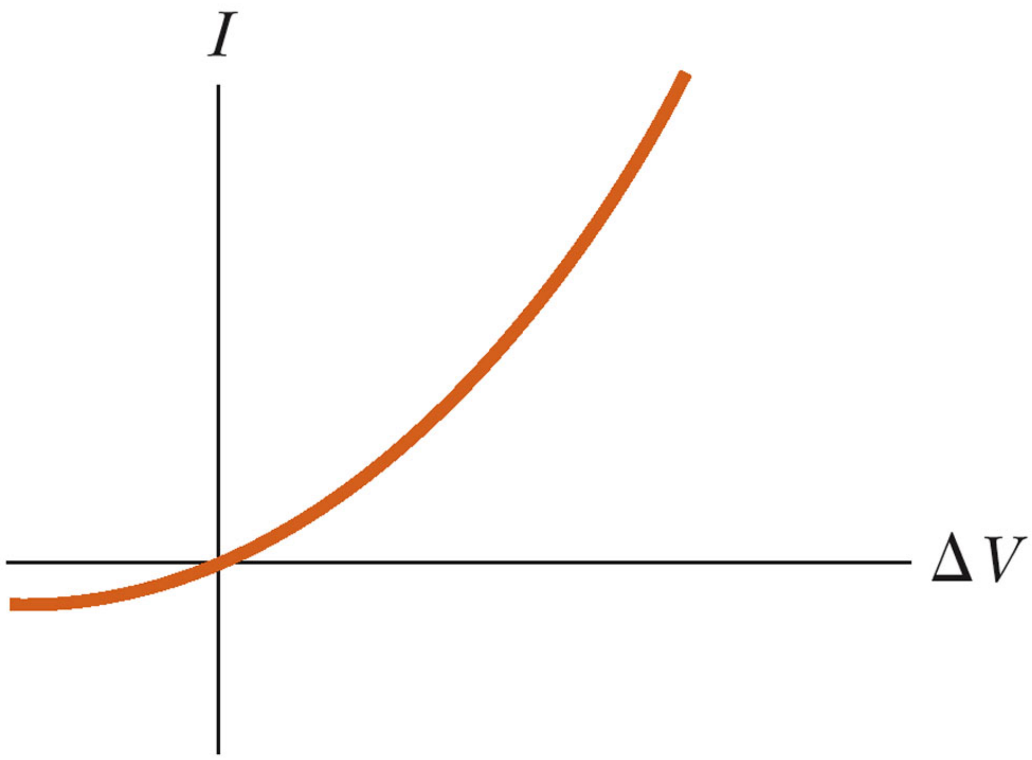
Ohm's Law, cont

- An ohmic device
- The resistance is constant over a wide range of voltages
- The relationship between current and voltage is linear
- The slope is related to the resistance



Ohm’s Law, final

- Non-ohmic materials are those whose resistance changes with voltage or current
- The current-voltage relationship is nonlinear
- A diode is a common example of a non-ohmic device



Resistivity

- The resistance of an ohmic conductor is proportional to its length, L, and inversely proportional to its cross-sectional area, A

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

  - ρ is the constant of proportionality and is called the *resistivity* of the material
  - See table 17.1

TABLE 17.1

Resistivities and Temperature Coefficients of Resistivity for Various Materials (at 20°C)

Material	Resistivity ($\Omega \cdot m$)	Temperature Coefficient of Resistivity [$(°C)^{-1}$]
Silver	1.59×10^{-8}	3.8×10^{-3}
Copper	1.7×10^{-8}	3.9×10^{-3}
Gold	2.44×10^{-8}	3.4×10^{-3}
Aluminum	2.82×10^{-8}	3.9×10^{-3}
Tungsten	5.6×10^{-8}	4.5×10^{-3}
Iron	10.0×10^{-8}	5.0×10^{-3}
Platinum	11×10^{-8}	3.92×10^{-3}
Lead	22×10^{-8}	3.9×10^{-3}
Nichrome[a]	150×10^{-8}	0.4×10^{-3}
Carbon	3.5×10^{5}	-0.5×10^{-3}
Germanium	0.46	-48×10^{-3}
Silicon	640	-75×10^{-3}
Glass	10^{10}–10^{14}	
Hard rubber	$\approx 10^{13}$	
Sulfur	10^{15}	
Quartz (fused)	75×10^{16}	

[a]A nickel–chromium alloy commonly used in heating elements.

Electrical Energy and Power, cont

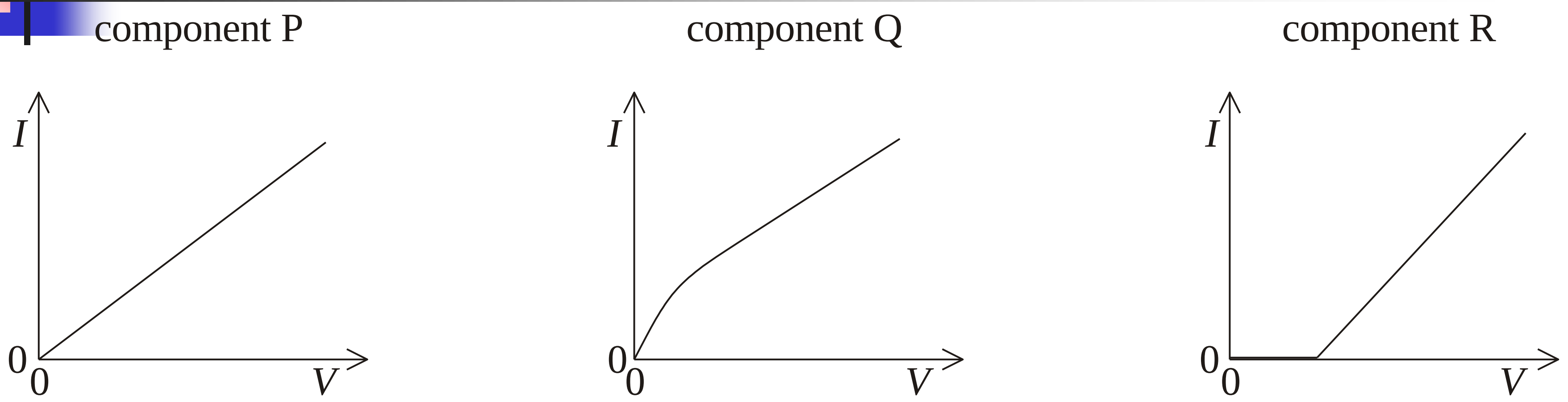
- The rate at which the energy is lost is the power

$$\wp = \frac{\Delta Q}{\Delta t}\Delta V = I\Delta V$$

- From Ohm's Law, alternate forms of power are

$$\wp = I^2 R = \frac{\Delta V^2}{R}$$

The graphs below are the current-voltage (I-V) characteristics of three electrical components P, Q and R.



Which component(s) has (have) constant resistance?

A. P only

B. R only

C. P and Q only

D. P and R only

Which of the following is a unit for electrical resistance?

A. WA^{-2}
B. AV^{-1}
C. $VW^{-2}s$
D. WV^{-2}