ohm's Law

- We know that:

$$J = \frac{I}{A}$$

and;

$$El = \Delta V$$

-

$$\begin{aligned} \mathbf{J} &= \sigma \mathbf{E} \\ \frac{I}{A} &= \sigma \frac{\Delta V}{l} \\ I &= \sigma \frac{A}{l} \Delta V \\ I &= \frac{A}{l\rho} \Delta V \\ I &= \frac{\Delta V}{R} \end{aligned}$$

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Figure 27.10

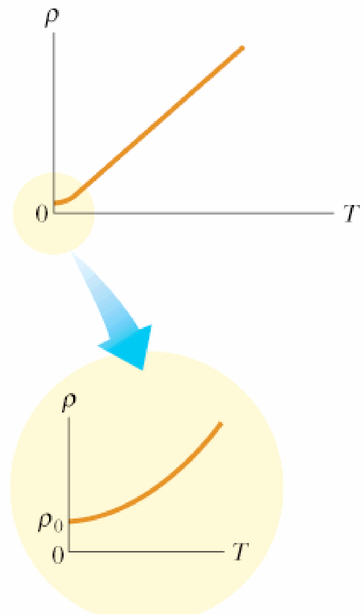

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Figure 27.11

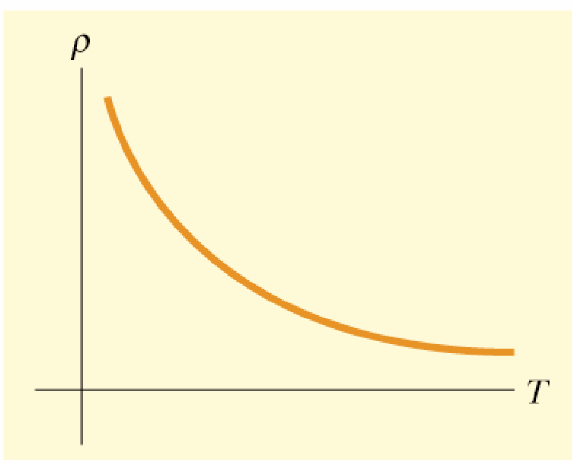

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Figure 27.12

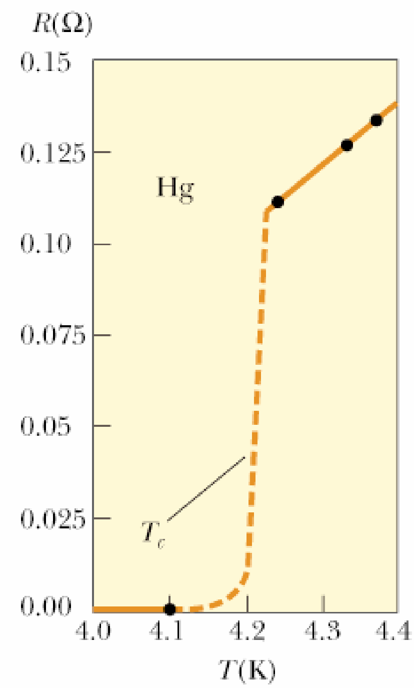

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Figure 27.13

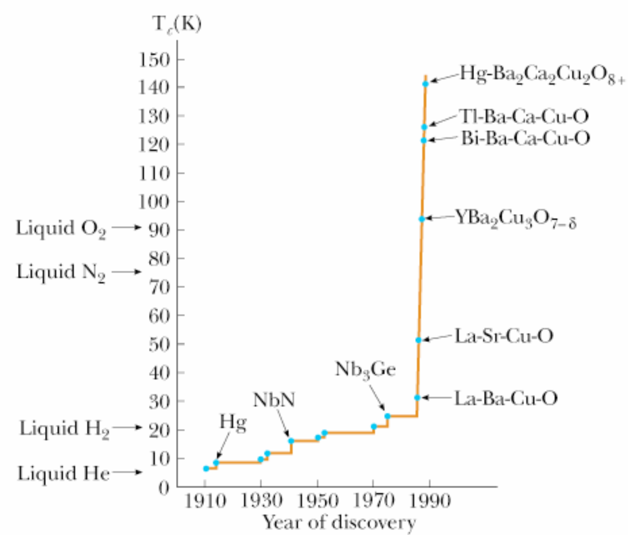

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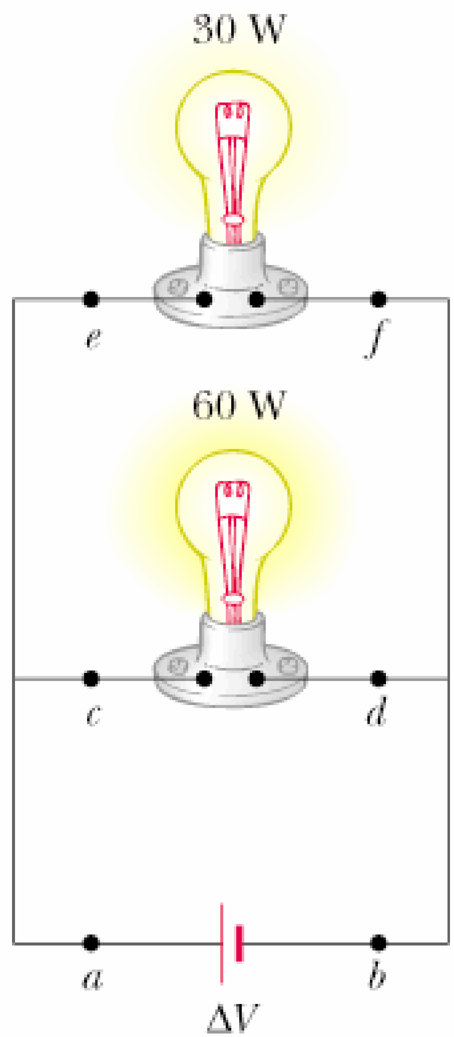
Figure 27.17



electromotive force

- A battery is a source of **electromotive force** (*emf*). It moves charges "uphill' from a lower potential to a higher potential.
- When positive charges are moved from the negative terminal to the positive terminal, the potential increases by ε,
- but since we have to work against the internal resistance r of the battery, there is a loss of potential by Ir.
- The terminal voltage of the battery:

$$\Delta V = \varepsilon - Ir \tag{1}$$

- The *emf* ε is equal to the **open-circuit voltage**, (when the current is zero)

$$\begin{aligned} \Delta V &= IR \\ &= \varepsilon - Ir \\ \varepsilon &= I(R + r) \end{aligned}$$

-

$$I = \frac{\varepsilon}{R + r}$$

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Figure 28.1

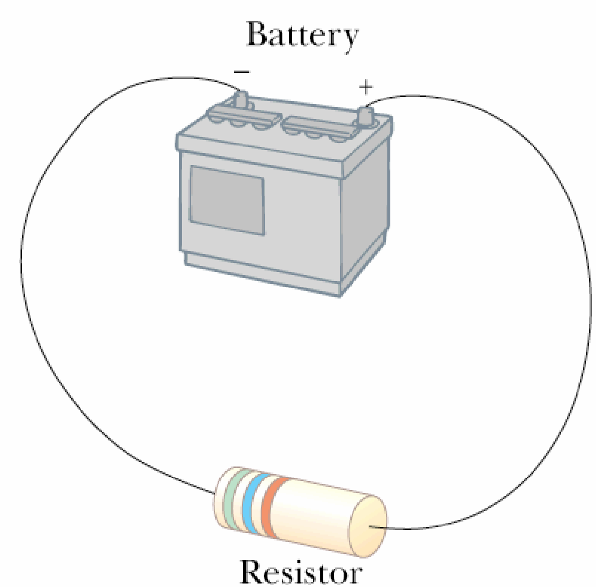

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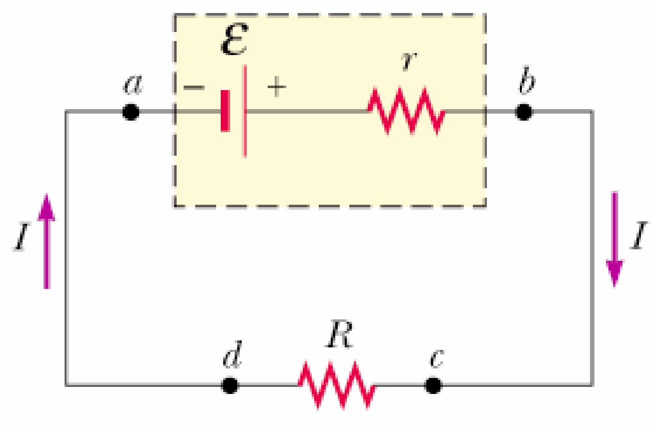
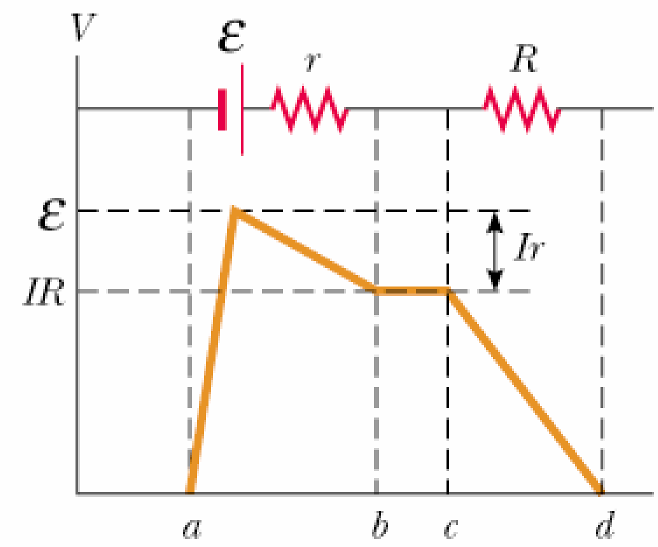
Figure 28.2



(a)



(b)

Electrical energy and power

- Amount of energy released when ΔQ moves across ΔV

$$\Delta U = \Delta Q \Delta V$$

- **Rate** at which this energy is released: **Power**

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t} \Delta V$$

$$P = I \Delta V$$

-

$$P = I \Delta V = I^2 R = \frac{(\Delta V)^2}{R}$$

- Unit of power is **watt:** W (Js^{-1})

Combination of Resistors

Series combination

- **The currents in the resistors connected in series are the same**
- For a series combination total voltage ΔV,

$$\Delta V = \Delta V_1 + \Delta V_2 \tag{10}$$

- Because the currents are the same:

$$\Delta V_1 = I R_1 \quad \Delta V_2 = I R_2 \tag{11}$$

- For a resistor equivalent to the combination;

$$\Delta V = I R_{eq} \tag{12}$$

- Substituting:

$$I R_{eq} = I R_1 + I R_2 \tag{13}$$
$$R_{eq} = R_1 + R_2 \tag{14}$$

- For a series combination of many resistors:

$$R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots \tag{15}$$

- **The equivalent resistance of a series combination of resistors is greater than any of the individual resistors.**

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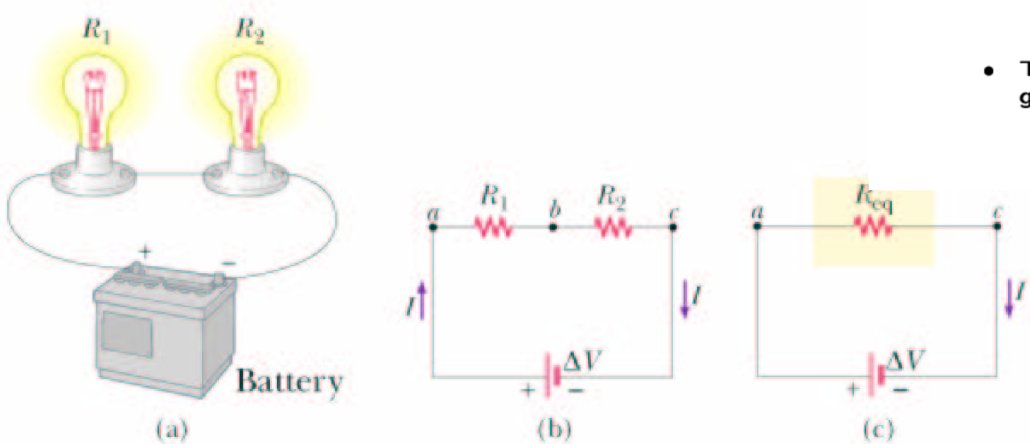
Figure 28.4



Parallel combination

- The individual potential differences across resistors connected in parallel are all the same and are equal to the potential difference applied across the combination.
- For a parallel combination total current,

$$I = I_1 + I_2 \tag{16}$$

- Substituting:

$$\frac{\Delta V}{R_{eq}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2} \tag{17}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{18}$$

- For a series combination of many capacitors:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \dots\dots\dots\dots \tag{19}$$

- **The equivalent resistance of a parallel combination of resistors is always less than any individual resistance in the combination.**

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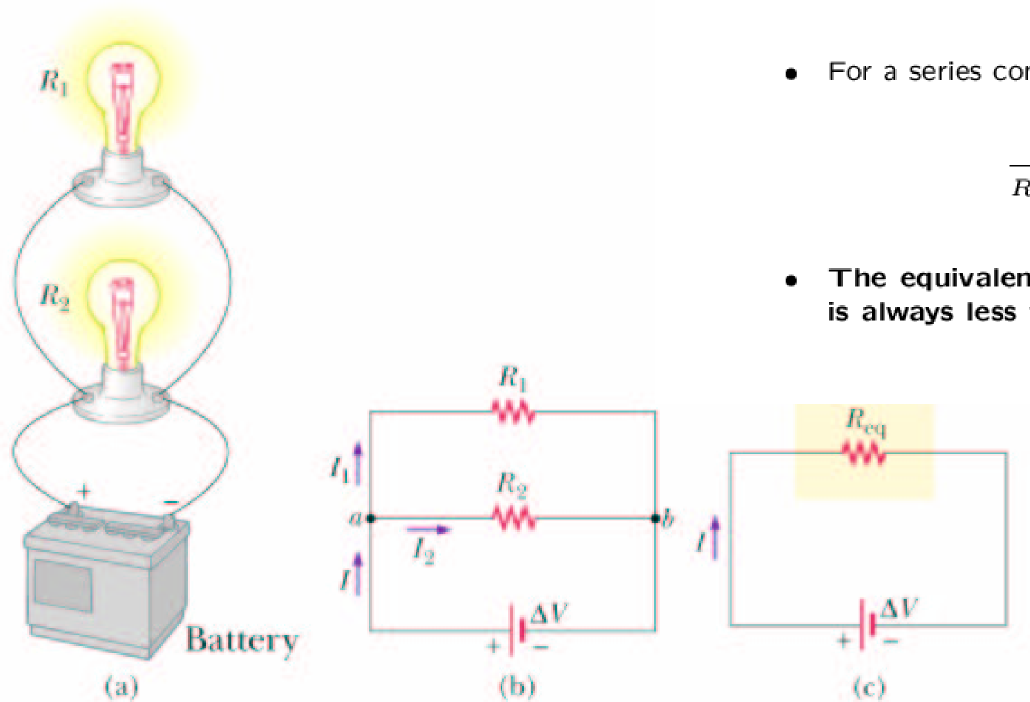
Figure 28.5



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a. Find the resistance between a and c
b. if the potential difference between a and c is 42 V, what is the current in each resistor ?

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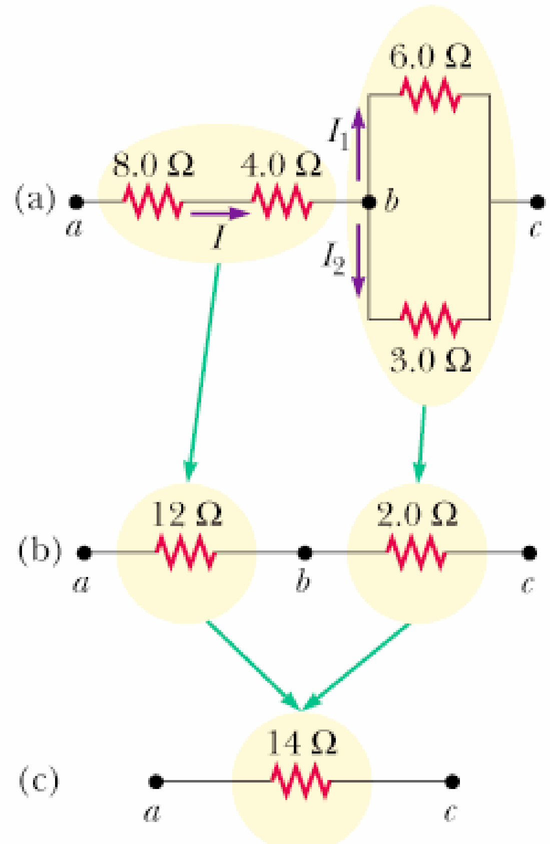
Figure 28.6



a. Find the current in each resistor
b. Power delivered to each resistor and total power delivered
c. Equivalent resistance

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Figure 28.7

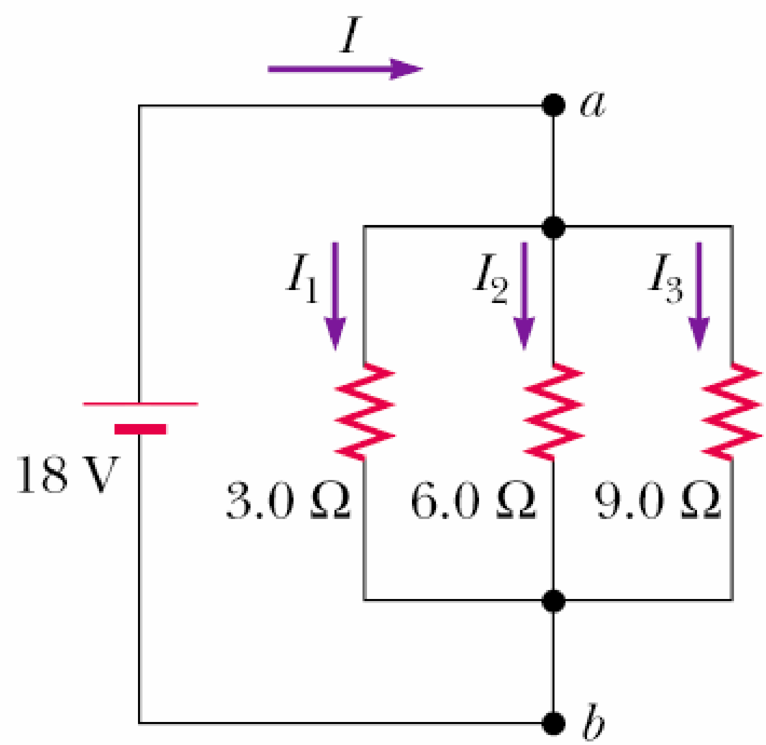

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Figure 28.8