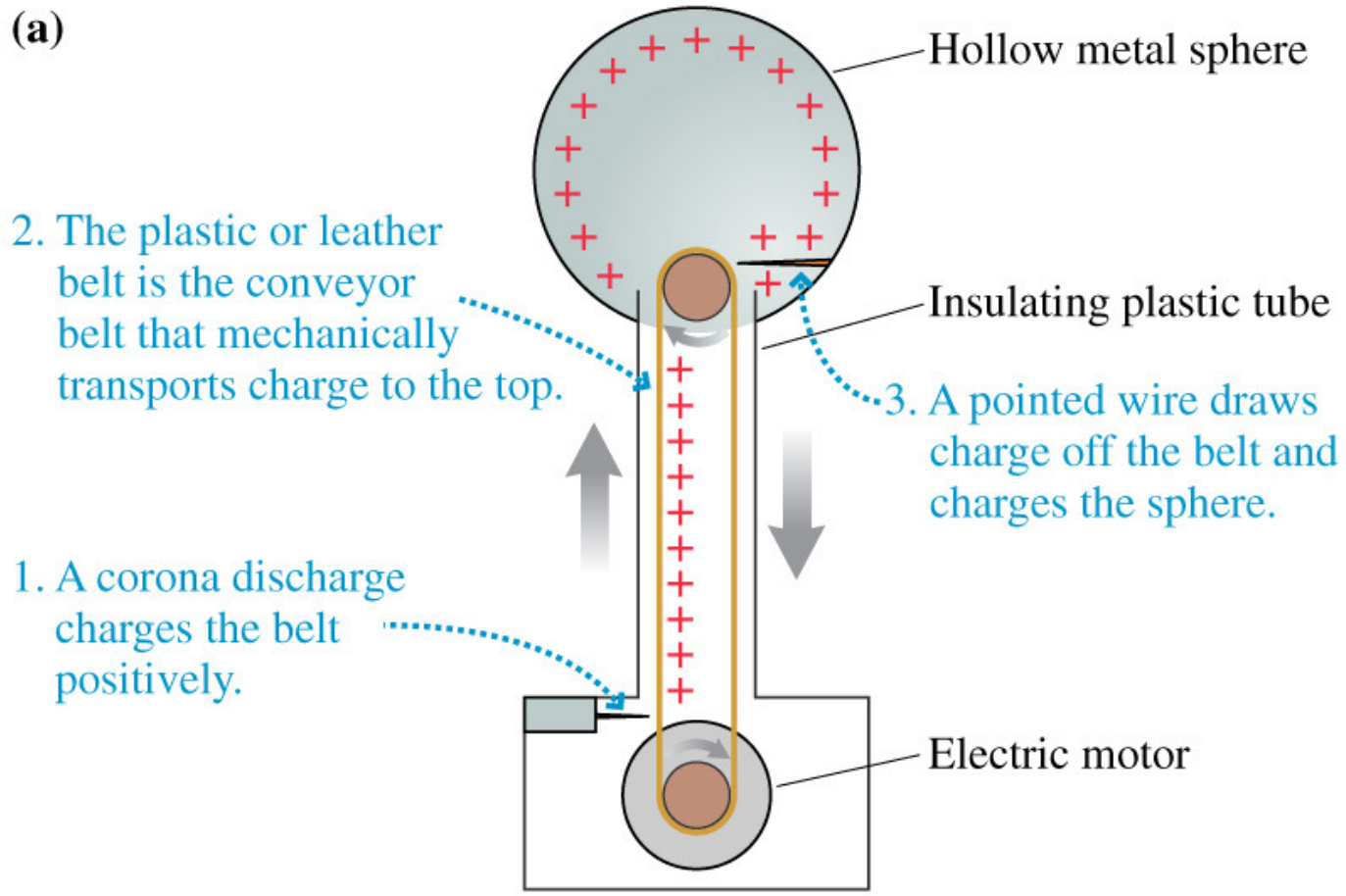


More on circuits

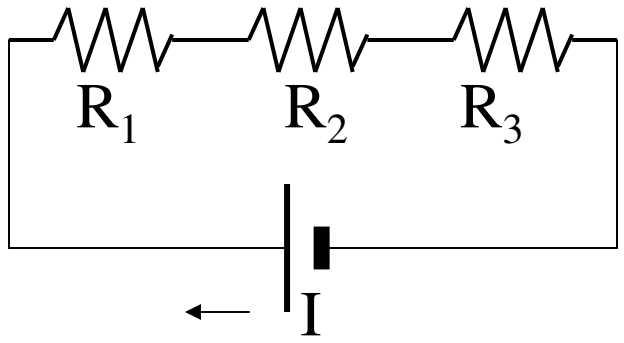
(Above: Van De Graaff generator)

More on circuits: review

- Series resistors: a) the current flowing through each resistor is the same as the total current drawn from the battery; b) the potential differences across the resistors add and the sum is equal to the battery voltage.

- The equivalent resistance of the circuit:

$$R_{eq} = R_1 + R_2 + R_3$$

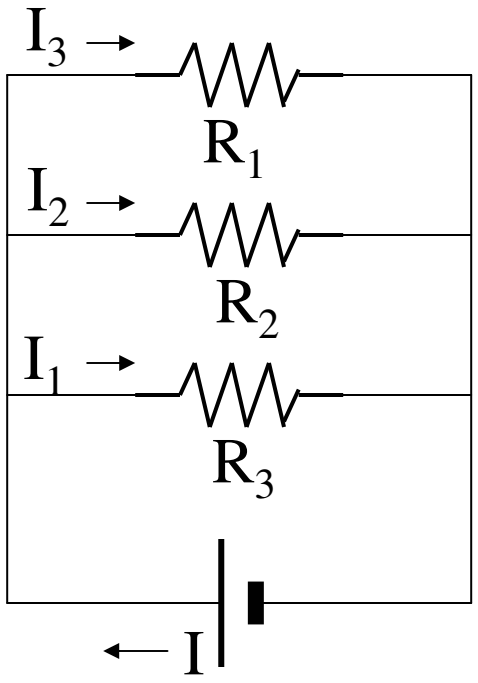


Parallel resistors

a) The potential difference across each resistor is the same; b) the currents flowing through each branch must add up to yield the total current drawn from the battery.

- Equivalent resistance

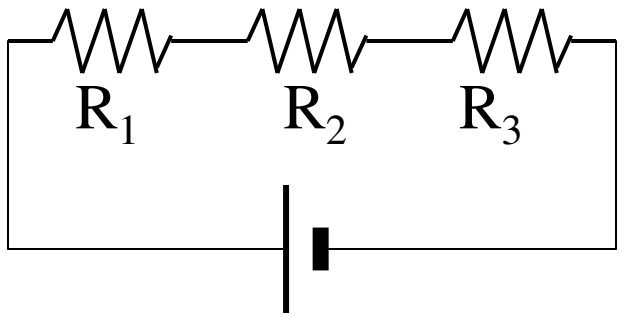
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



Q1

- As more resistors *R* are added to a series circuit, the current drawn from the battery

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



1. increases.
2. remains the same.
3. decreases.

Q2

The equivalent resistance for a group of parallel resistors is

1. less than any resistor in the group.
2. equal to the smallest resistance in the group.
3. equal to the average resistance of the group.
4. equal to the largest resistance in the group.
5. larger than any resistor in the group.

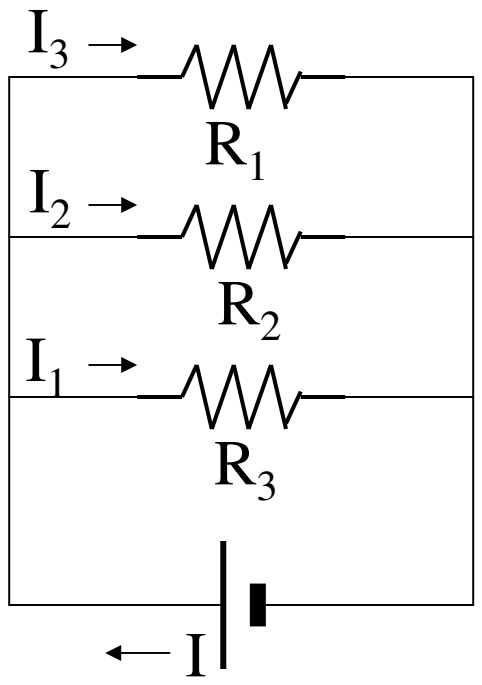
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Q3

As more resistors *R* are added to a parallel circuit, the total current drawn from the battery

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

1. increases.
2. remains the same.
3. decreases.



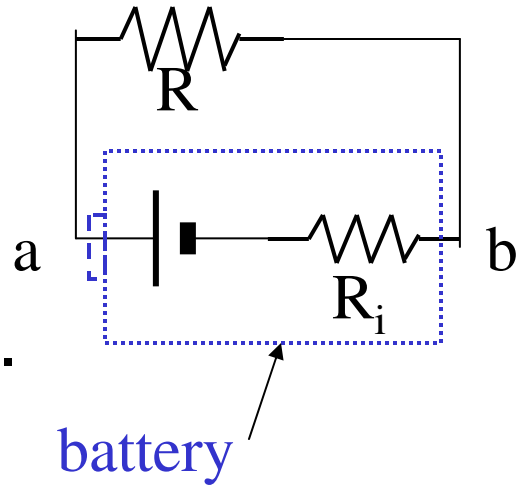
Terminal Voltage

- Ideal battery: ε is the work is done by an electrochemical reaction in order to separate charges.

$$\varepsilon = \frac{W_{chem}}{q}$$

- Terminal voltage $\Delta V_{ab} < \varepsilon$ due to internal resistance R_i in real batteries.

$$\Delta V_{ab} = \varepsilon - I \cdot R_i$$

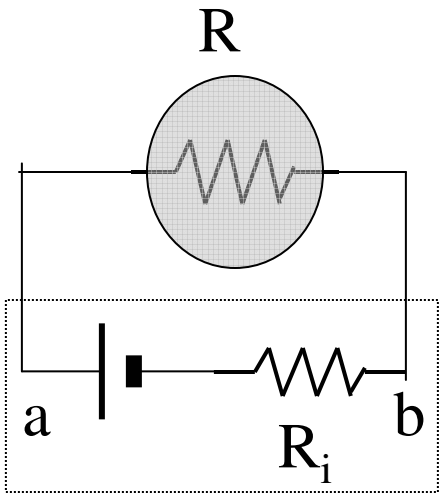


- The internal resistance is in series with the **load resistance R**, i.e., the resistance of the external electric circuit.

Q4

A light bulb having a resistance R is connected to a battery. If the light bulb is replaced with another light bulb having a larger resistance, the terminal voltage ΔV_{ab} of the battery

1. increases with increasing R
2. decreases with increasing R
3. remains the same.



Q5

- When you connect a light bulb to a battery and a current flows through the circuit, which is true?

1. Electric energy is conserved.
2. Total energy is conserved.
3. Charges are absorbed in the thin wire inside the bulb causing the wire to glow.
4. All of the electric energy is transformed into light.
5. All statements above are true.
6. All statements are above false.

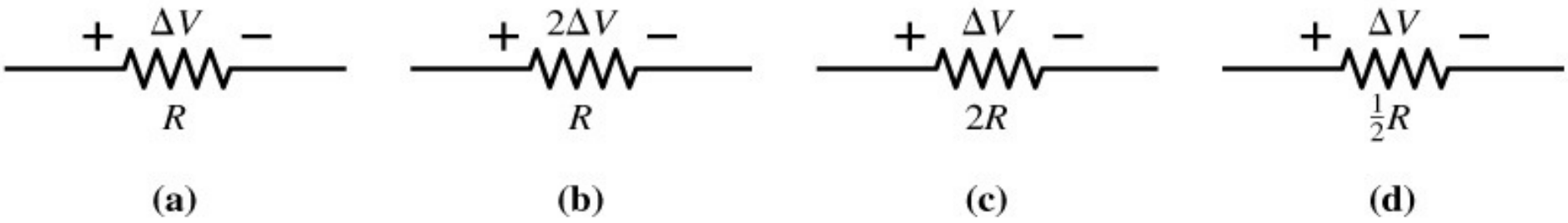
Electrical Power

- $P = \Delta V\ I$
- Unit: Watt (W) = V A
- kW, MW, GW

- In circuits, charges do work on light bulbs, appliances, etc. and electric energy is transformed into other forms of energy (food blender example).

Q6

Rank in order, from largest to smallest, the powers P_a to P_d dissipated in resistors a to d.



1. $P_b > P_a = P_c = P_d$
2. $P_b = P_c > P_a > P_c$
3. $P_b = P_d > P_a > P_c$
4. $P_b > P_c > P_a > P_d$
5. $P_b > P_d > P_a > P_c$

Electrical Energy Dissipation

- Is the energy that is lost as heat (due to resistance) every second.
- Power $P = I \cdot \Delta V$ (in general)
- using $R = \Delta V/I$, we obtain

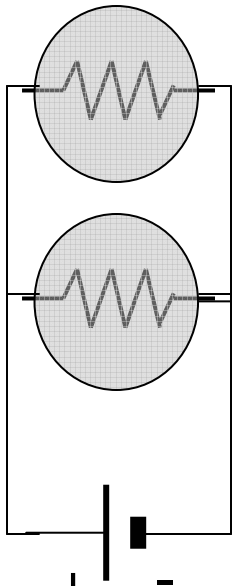
  $P = I^2 \cdot R$ or $P = \Delta V^2/R$

  These equations apply only to the transfer of electrical energy into thermal energy in a resistive material: Useful for light bulbs, space heaters, computers, etc.
- The equation $P = I \Delta V$ applies to all kinds of electrical energy transfer.

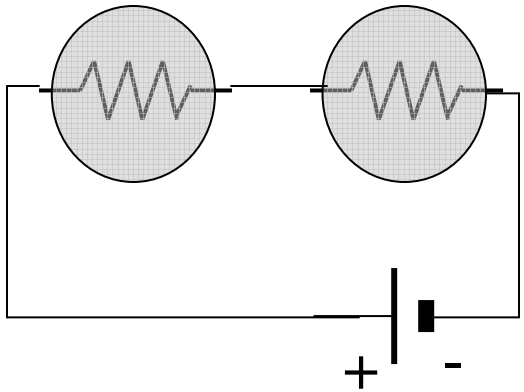
Q7

- If the four light bulbs in the figure are identical, which circuit emits more light (more power)?

  1) Circuit I 2) Circuit II 3) Both emit the same amount of light.



I

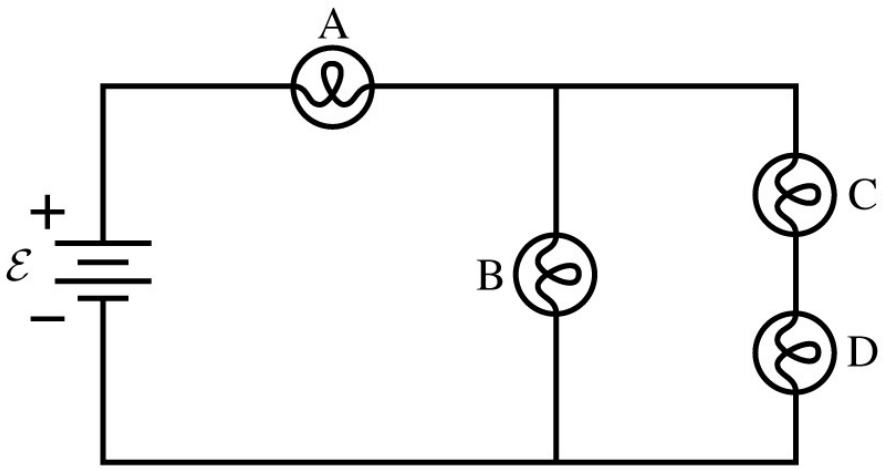


II

Q8

Rank in order, from brightest to dimmest, the identical bulbs A to D.

1. A = B = C = D
2. A > B > C = D
3. A > C > B > D
4. A > C = D > B
5. C = D > B > A



Short Circuits

- Sometimes faulty appliances can lead to short circuits (often due to overheating, moisture buildup on circuit boards, etc.)
- Short circuit: Positive and negative terminal connected by very small resistance leading to large currents.
- Household wiring and can only handle current of fixed amount ~ 15A. Larger currents can damage the wire.
- (Nail burner demo)