

**Part A: Concepts**

1. For each description, write **current**, **voltage**, or **resistance**.

- the energy a battery gives to each coulomb of charge
- the number of coulombs passing a point each second
- how strongly a material opposes the flow of charge
- measured in amperes (A)
- measured in ohms ( $\Omega$ )
- in the water analogy, the narrow section of pipe
- in the water analogy, the push from the pump

**a.** voltage   **b.** current   **c.** resistance   **d.** current   **e.** resistance   **f.** resistance   **g.** voltage

2. The four wires below all have the same temperature. Rank them from **least** to **most** resistance, and give a reason for each step in your ranking.

- |          |                                                                                     |                      |
|----------|-------------------------------------------------------------------------------------|----------------------|
| <b>A</b> |    | copper, 1 m          |
| <b>B</b> |   | copper, 2 m          |
| <b>C</b> |  | copper, 2 m (thin)   |
| <b>D</b> |  | nichrome, 2 m (thin) |

**Ranking: A < B < C < D**

A < B: same material and thickness, but B is longer, so charges bump into more atoms.

B < C: same material and length, but C is thinner, so there is less room for charge to flow.

C < D: same size, but nichrome has much higher resistance than copper.

**Part B: Current**

Use  $I = q/t$ . Show your knowns, equation, substitution, and answer with units.

3. A total charge of 18 C flows through a portable speaker in 12 s. What is the current in the speaker?

**Knowns:**  $q = 18 \text{ C}$ ,  $t = 12 \text{ s}$

**Equation:**  $I = q/t$

**Substitute:**  $I = 18 \text{ C} / 12 \text{ s}$

**Answer:**  $I = 1.5 \text{ A}$

4. A phone charger delivers a current of 2.0 A for 15 minutes. How much charge flows into the phone? (Hint: change the time to seconds first.)

**Knowns:**  $I = 2.0 \text{ A}$ ,  $t = 15 \text{ min} \times 60 \text{ s/min} = 900 \text{ s}$

**Equation:**  $I = q/t$ , so  $q = It$

**Substitute:**  $q = (2.0 \text{ A})(900 \text{ s})$ . An amp is a coulomb per second, so the seconds cancel.

**Answer:**  $q = 1800 \text{ C} = 1.8 \times 10^3 \text{ C}$

5. A desk lamp bulb carries a current of 0.80 A. How long does it take for 240 C of charge to pass through it? Give your answer in seconds and in minutes.

**Knowns:**  $I = 0.80 \text{ A}$ ,  $q = 240 \text{ C}$

**Equation:**  $I = q/t$ , so  $t = q/I$

**Substitute:**  $t = 240 \text{ C} / 0.80 \text{ A}$

**Answer:**  $t = 300 \text{ s} = 5.0 \text{ min}$

## Part C: Voltage

Use  $\Delta V = PE/q$ .

6. A battery pack gives 27 J of energy to 6.0 C of charge. What is its voltage? The pack is made of 1.5 V cells. How many cells does it hold?

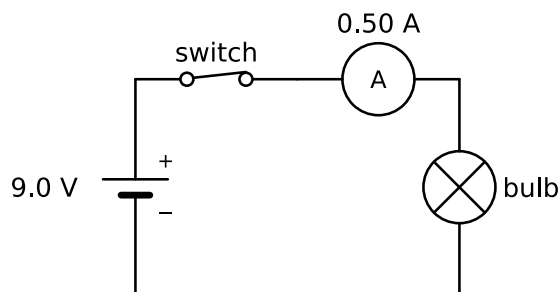
**Knowns:**  $PE = 27 \text{ J}$ ,  $q = 6.0 \text{ C}$

**Equation:**  $\Delta V = PE/q$

**Substitute:**  $\Delta V = 27 \text{ J} / 6.0 \text{ C}$

**Answer:**  $\Delta V = 4.5 \text{ V}$ . Each cell gives 1.5 V, so  $4.5 \text{ V} / 1.5 \text{ V} = 3 \text{ cells}$ .

7. Ana's flashlight circuit is shown. The ammeter reads 0.50 A, and she leaves the flashlight on for 60.0 s.



- a. How much charge passes through the bulb?  
b. How much energy does the battery give to that charge?  
c. Ana swaps in a bulb with more resistance. What happens to the current? Explain.

**a. Knowns:**  $I = 0.50 \text{ A}$ ,  $t = 60.0 \text{ s}$  **Equation:**  $q = It$  **Substitute:**  $q = (0.50 \text{ A})(60.0 \text{ s})$

**Answer:**  $q = 30. \text{ C}$

**b. Knowns:**  $\Delta V = 9.0 \text{ V}$ ,  $q = 30. \text{ C}$  **Equation:**  $PE = q\Delta V$  **Substitute:**  $PE = (30. \text{ C})(9.0 \text{ V})$

**Answer:**  $PE = 270 \text{ J}$

**c.** The current **decreases**. The battery gives the same push (9.0 V), but more resistance opposes the flow more, so fewer coulombs pass each second.