What is TRUE about the potential and electric field at point “P”?

a) $V=0$, $E$ towards $-Q$

b) $V=0$, $E=0$

c) $V=2kQ/R$, $E=0$

d) $V=2kQ/R$, $E$ towards $-Q$

Point Charge

$V(r) = \frac{kQ}{r}$

Point Charge

$\vec{E}(r) = \frac{kQ}{r^2} \hat{r}$
ICLICKER QUESTION

A circular arc has a total charge $+Q$. What is TRUE about the electric field at point $p$?

a) $E=0$

b) $E$ is directed to the right of “p” horizontally.

c) $E$ is directed from “p” below the horizontal.

d) $E$ is directed from “p” above the horizontal.

e) None of the above are true.
ICLICKER QUESTION

Which statement is TRUE for point P?

- a) At P, \( V = 0 \), \( E = 0 \)
- b) At P, \( V = 0 \), \( E \) is 45°
- c) At P, \( V = 0 \), \( E \) is 225°
- d) At P, \( V \neq 0 \), \( E = 0 \)
- e) At P, \( V \neq 0 \), \( E \) is 225°
The Electric Battery

- Volta discovered that electricity could be created if dissimilar metals were connected by a conductive solution called an electrolyte.

This is a simple electric cell:
The Electric Battery

• A battery transforms chemical energy into electrical energy.

• Chemical reactions within the cell create a nearly constant potential difference between the terminals by slowly dissolving them.

• This potential difference can be maintained even if a current is kept flowing, until one or the other terminal is completely dissolved.
The Electric Battery

- Several cells connected make a battery.
Electric current \((I)\) is the rate of flow of charge through a conductor:

Electric current: \[ I = \frac{dQ}{dt} \]

Average electric current: \[ I_{ave} = \frac{\Delta Q}{\Delta t} \]
Unit of Electric Current

Unit of electric current: the ampere, A.

1 A = 1 C/s

André-Marie Ampère
A Complete Circuit

• A complete circuit is one where current can flow all the way around.

• In a closed circuit the flow of current is from high-to-low electric potential.
ICLICKER QUESTION

Which is the correct way to light the lightbulb with the battery?

a) i
b) ii

\[\boxed{c) \text{ iii}}\]
d) All are correct
e) None are correct
ICLICKER QUESTION

The flow of current in a circuit is from high-to-low electric potential. In which direction is the electron flow.

a) The same as the current.

b) Opposite to that of the current.

c) Neither, electrons stay where they are.
A Complete Circuit

- Note that the flow of electrons \( q_{el} = -e \) is opposite to that of the current.
Ohm’s Law: Resistance and Resistors

Experimentally, it is found that the current in a wire is proportional to the potential difference between its ends:

\[ I \propto V \]

The proportionality constant “R” is called the resistance:

\[ V = IR \]
Ohm’s Law

In many conductors, the resistance is independent of the voltage; this relationship is called Ohm’s law.

\[ \frac{\Delta I}{\Delta V} = \frac{1}{R} \]

Materials that do not follow Ohm’s law are called nonohmic.
Unit of Resistance

Unit of resistance: the ohm, $\Omega$.

$1 \Omega = 1 \text{ V/A}$

Georg Ohm
ICLICKER QUESTION

On a certain conductor you notice that when you double the voltage across it the current increases by a factor of 3. What can you conclude?

a) Ohm’s law is obeyed since current increased with increasing voltage.

b) Ohm’s law is not obeyed.

c) This has nothing to do with Ohm’s law.
Resistivity

The resistance of a wire is directly proportional to its length and inversely proportional to its cross-sectional area:

\[ R = \rho \frac{\ell}{A} \]

The resistivity, \( \rho \), is characteristic of the material.
Resistivity

For any given material*, the resistivity increases with temperature:

\[ \rho_T = \rho_0 [1 + \alpha (T - T_0)] \]

- \( \alpha \) is the Temperature coefficient.

* Semiconductors may have resistivities that decrease with temperature.
Iclicker Question

Two wires, 1 and 2, are made of the same metal and have equal length, but the resistance of wire 1 is four times the resistance of wire 2. How do their diameters compare?

\[ R = \rho \frac{\ell}{A} \]

- **a)** \( d_1 = 4d_2 \)
- **b)** \( d_1 = 2d_2 \)
- **c)** \( d_1 = d_2 \)
- **d)** \( d_1 = \frac{1}{2}d_2 \)
- **e)** \( d_1 = \frac{1}{4}d_2 \)

\[ R_1 = 4R_2 \]

\[ \rho_1 = \rho_2 \quad \ell_1 = \ell_2 \]

\[ \frac{1}{A_1} = 4 \frac{1}{A_2} \Rightarrow A_2 = 4A_1 \Rightarrow \left( \pi \frac{D_2}{2} \right) = 4 \left( \pi \frac{D_1}{2} \right) \]

\[ D_2 = 2D_1 \]