Show your work!!! If I can read it, I will give you partial credit!!! Correct answers without work will NOT get full credit.

Concept (3 points)

1. In your own words, state Ohm’s Law. Is it always valid? If it is, give an example of when it is valid, if it is not, also give an example of when it is not valid.

Ohm’s law relates the voltage with the current and resistance in circuit:

\[ V = iR \]

The equation is only valid for components which are ohmic in nature; i.e. those whose resistivity is independent of the applied electric field:

\[ \rho \neq \rho(\vec{E}) \]

An example of Ohm’s law is circuit with a resistor. An example of when the law does not apply is for a transistor.
2. An isolated conducting sphere has a radius \( r = 10 \text{cm} \). One wire carries a current of \( i_{\text{in}} = 1.000002 \text{A} \) to the sphere, and another wire carries \( i_{\text{out}} = 1.000000 \text{A} \) off of the sphere. How long will it take for the sphere to increase in potential by \( V = 1 \text{kV} \)?

\( (k=8.99 \times 10^9 \text{N} \cdot \text{m}^2/\text{C} \text{ and } \varepsilon_0=8.85 \times 10^{-12} \text{C}/(\text{N} \cdot \text{m}^2)) \)

The potential on the sphere is:

\[
V = k \frac{q}{r}
\]

and the change in potential is:

\[
\Delta V = k \frac{\Delta q}{r}
\]

such that:

\[
\Delta q = \frac{r \Delta V}{k}
\]

Also, since:

\[
\Delta i = i_{\text{in}} - i_{\text{out}} = \frac{\Delta q}{\Delta t}
\]

One can solve this for \( \Delta t \):

\[
\Delta t = \frac{\Delta q}{i_{\text{in}} - i_{\text{out}}}
\]

Substituting in for \( \Delta q \):

\[
\Delta t = \frac{\Delta q}{i_{\text{in}} - i_{\text{out}}} = \frac{r \Delta V}{k(i_{\text{in}} - i_{\text{out}})} = \frac{0.1 \text{m} \cdot 1000 \text{N} \cdot \text{m}}{(8.99 \times 10^9 \text{N} \cdot \text{m}^2/\text{C})(1.000002 \text{A} - 1.000000 \text{A})}
\]

or

\[
\Delta t = 5.56 \times 10^{-8} \text{s} = 5.56 \text{ms}
\]