3. (12 pts) A spherical satellite is given a charge of $-6.5 \, \mu C$, which lowers its voltage by $130 \, V$ relative to a space station that is $15 \, \text{km}$ away. Determine the capacitance and radius of the satellite. Estimate how much charge on the space station would return the satellite to its initial voltage.

\[
\Delta V = \frac{k \Delta q}{R} = \frac{\Delta q}{C}, \quad \text{Thus} \quad C = \frac{\Delta q}{\Delta V} = \frac{-6.5 \, \mu C}{-130 \, V} = 0.05 \, \mu F.
\]

Also, \( R = \frac{k \Delta q}{\Delta V} = kC = 449.38 \, \text{m} \)

Now want \( \Delta V' = \frac{k \Delta q'}{R} = \frac{130 \, V}{R} \)

So \( \Delta q' = \frac{R}{k} (130 \, V) = 2.167 \times 10^{-6} \, C = 2.167 \, \mu C \).

4. A voltaic cell has internal resistance \( r = 0.3 \, \Omega \) and open circuit voltages across the left and right electrodes of $0.4 \, V$ and $1.6 \, V$, for a net emf of $E = 1.2 \, V$. It is in series with a resistor $R = 0.7 \, \Omega$. Let $V_a = 0.4 \, V$. The connecting wires have zero resistance.

a. (12 pts) Find the current, the voltage drops across the resistances, and sketch the voltage around the circuit. (Hint: start from point d.)

\[ I = \frac{E}{R + r} = \frac{1.2}{0.3 + 0.7} = 1.2 \, A \]

\[ IR = 0.36 \, V, \quad IR = 0.84 \, V \]

b. (6 pts) The cell discharges in 42 minutes; find its initial "charge" and energy.

\[ Q = IT = (1.2 \, A) (42 \times 60 \, s) = 3024 \, C \]

\[ E = QE = 3629 \, J \]

5. (10 pts) Find the unknown currents for the circuit in the figure.

\[ I = 12 \, A, \quad \delta I_{10} = \delta I_{14} = \frac{\Delta V + 12}{14} \]

\[ I = I_{10} + I_{14}. \]

\[ \delta I_{16} + \frac{12 + \delta I_{16}}{14} = \frac{12}{2} \quad \Delta V \left( \frac{1}{10} + \frac{1}{14} \right) = \frac{12}{14} + \frac{12}{10} = \frac{3}{2} \]

\[ \delta I_{12} = \frac{12 + \delta I_{12}}{14}, \quad \frac{12 + 12}{14} = \frac{12}{24} \]

\[ \Delta V = 12 \frac{12}{14} + \frac{10 + 14}{10 + 14} = \frac{12}{24} \]

\[ I_{10} = \frac{65}{10} = 6.5 \, A, \quad I_{14} = \frac{77}{14} = 5.5 \, A \]

\[ \delta I_{10} + \delta I_{14} = 12 \, A = I \]

\[ 2 \]