3. (12 pts) A spherical satellite is given a charge of 4.5 μC, which raises its voltage by 80 V relative to a space station that is 13 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. $\leftarrow \Delta q$ Yellow

$$\Delta V = \frac{k\Delta q}{r} = \frac{\Delta q}{C}. \text{ Thus } C = \frac{\Delta q}{\Delta V} = \frac{4.5\mu C}{80V} = .05625\,\mu F$$

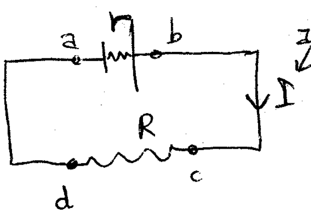
$$\text{Also, } r = \frac{k\Delta q}{\Delta V} = kC = 506.25\text{ m}$$

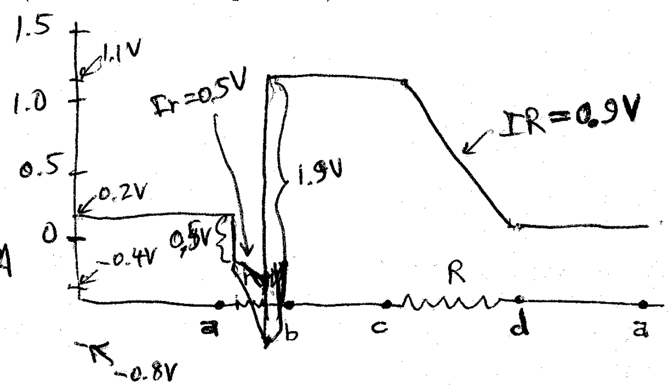
$$\text{Now want } \Delta V' = \frac{k q'_{s.s}}{R} = -80\text{ V},$$

$$\text{so } q'_{s.s.} = -\frac{R}{k}(80V) = -1.156\times10^{-4}C = -115.6\,\mu C$$

4. A voltaic cell has internal resistance $r = 0.25\ \Omega$ and open circuit voltages across the left and right electrodes of 0.5 V and 1.9 V, for a net emf of $\mathcal{E} = 1.4$ V. It is in series with a resistor $R = 0.45\ \Omega$. Let $V_d = 0.2$ 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.)





$$I = \frac{\mathcal{E}}{r+R} = \frac{1.4}{.25+.45} = \frac{1.4}{.7} = 2A$$

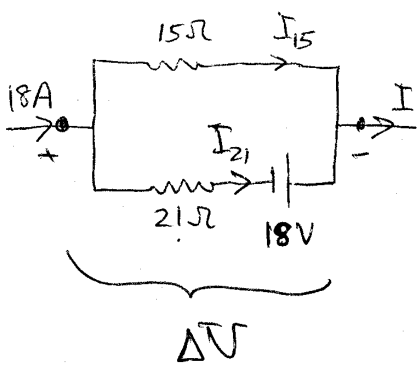
$$Ir = 0.5\text{ V},\ IR = 0.9\text{ V}$$

b. (6 pts) The cell discharges in 55 minutes; find its initial "charge" and energy.

$$Q = IT = (2A)(55\times60\,s) = 6600\text{ C}$$

$$E = Q\mathcal{E} = 9240\text{ J}$$

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



$$I = 18\text{ A}$$

$$I_{15} = \frac{\Delta V}{15}$$

$$I_{21} = \frac{18+\Delta V}{21}$$

$$I_{15} + I_{21} = I$$

$$\frac{\Delta V}{15} + \frac{18}{21} + \frac{\Delta V}{21} = 18$$

$$\Delta V\left(\frac{1}{15}+\frac{1}{21}\right) = 18 - \frac{18}{21} = 18\cdot\frac{20}{21}$$

$$\Delta V = 18\cdot\frac{20}{21}\cdot\frac{15\cdot21}{15+21} = \frac{18}{36}\cdot20\cdot15 = 150\text{ V}$$

$$I_{15} = \frac{150}{15} = 10A,\quad I_{21} = \frac{18+150}{21} = \frac{168}{21} = 8$$

$$I_{15} + I_{21} = 18A = I$$