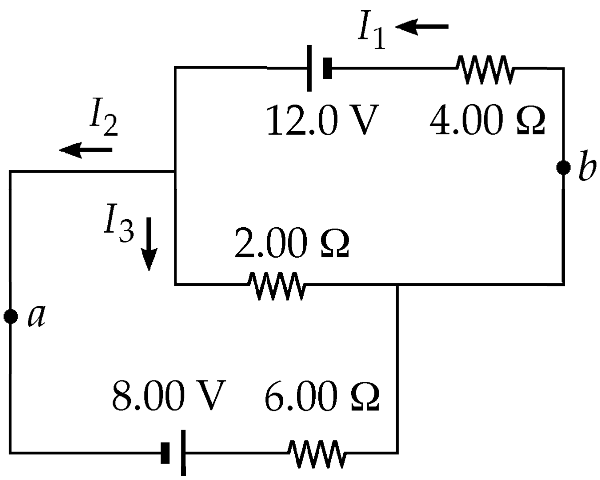

Figure 1: Problem 7.

Prof. Anchordoqui

Problems set # 7 **Physics 167** **Solutions**

1. For the circuit shown in Fig. 1, calculate *(i)* the current in the 2.00 Ω resistor and *(ii)* the potential difference between points a and b.

(i) We name the currents i_1, i_2, and i_3 as shown in the figure, and so $i_1 = i_2 + i_3$. Going countercolckwise around the loop we get, $12.0\ \mathrm{V} - 2.00\ \Omega\ i_3 - 4.00\ \Omega\ i_1 = 0$. Traversing the bottom loop we have $8\ \mathrm{V} - 6.00\ \Omega\ i_2 + 2.00\ \Omega\ i_3 = 0$. We can solve these last two equations for i_1 and i_2, yielding $i_1 = 3.00\ \mathrm{A} - \frac{1}{2} i_3$ and $i_2 = \frac{4}{3}\ \mathrm{A} + \frac{1}{3} i_3$. This means that $i_3 = 909$ mA. *(ii)* $V_a - 0.909\ \mathrm{A} \cdot 2.00\ \Omega = V_b$, then $V_b - V_a = -1.82$ V.

2. The heating element of an electric oven is designed to produce 3.3 kW of heat when connected to a 240-V source. What must be the resistance of the element?

Solution: Since $P = V^2/R$ we have $R = V^2/P = 17\ \Omega$.

3. A heater coil connected to a 240-$\mathrm{V_{rms}}$ AC line has a resistance of 38 Ω. *(i)* What is the average power used? *(ii)* What are the maximum and minimum values of the instantaneous power?

Solution: *(i)* The average power used can be found from the resistance and the rms voltage $\overline{P} = V_{\mathrm{rms}}^2/R = 1516$ W. *(ii)* The maximum power is twice the average power, $P_{\max} = 2\overline{P} = 3 \times 10^3$ W, and the minimum power is $P_{\min} = 0$.

4. At a point high in the Earth's atmosphere, He^{2+} ions in a concentration of $2.4 \times 10^{12}\ \mathrm{m}^{-3}$ are moving due north at a speed of 2.0×10^6 m/s. In addition, a $7.0 \times 10^{11}\ \mathrm{m}^{-3}$ concentration of

O_2^- ions is moving due south at a speed of 6.2×10^6 m/s. Determine the magnitude and direction of the net current passing through unit area A/m^2.

Solution: We are given a net charge, a concentration, and a speed (like the drift speed) for both types of ions. We can determine the current per unit area, $I/A = nev_d$. Both currents are in the same direction in terms of conventional current –positive charge moving north has the same effect as negative charge moving south– so they can be added: $I/A = (nev_d)_{\mathrm{He}} + (nev_d)_{\mathrm{O}} = 2.2\ \mathrm{A/m^2}$, north.

5. Consider the circuit shown in Fig. 2, with the start up switch T_1 open (for a long time). Now, close the switch and wait for a while. What is the change in the total charge of the capacitor if $V_2 > V_1$?

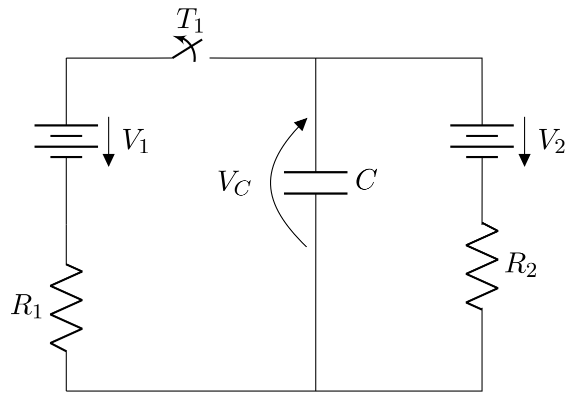

Figure 2: Problem 5.

Solution: While the switch remains open the charge in the capacitor is $q_i = V_2 C$. If we closed the switch and wait for a while we have $V_1 - V_2 + IR_2 + IR_1 = 0$ and so $I = \frac{V_2 - V_1}{R_1 + R_2}$. The voltage across the capacitor is $V_C = V_1 + IR_1 = V_1 + \left(\frac{V_2 - V_1}{R_1 + R_2}\right) R_1$. Hence, the change in the charge is $\Delta q = C\left(V_1 - V_2 + \frac{V_2 - V_1}{R_1 + R_2} R_1\right)$.