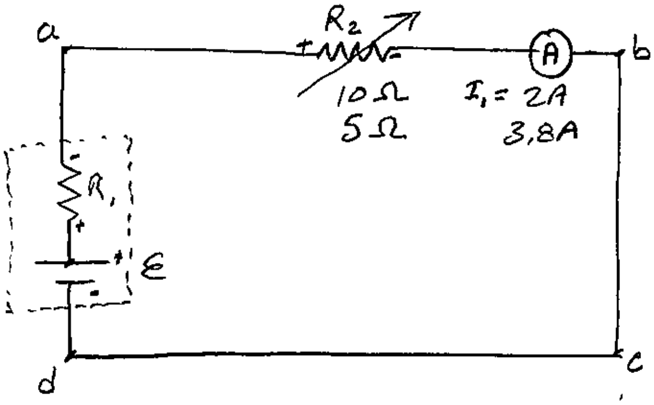
UCONN Physics Unit 13 — /50 — Name: KEY

Practice Quiz: I-L — Date: ________ Per ______

Resistivity, Power, Internal Resistance, Wheatstone bridge, & Capacitors

Show all of your work! Label all units!

1. A battery is connected in series with a variable resistor and an ammeter. When the resistance of the resistor is 10 Ω the current is 2.0 A. When the resistance is 5 Ω the current is 3.8 A. Find the emf and the internal resistance of the battery. 10 pts.



USE KIRCHOFF RULES KVL.

abcd: $-I_1R_2 + \mathcal{E} - I_1R_1 = 0$

$\mathcal{E} = I_1R_1 + I_1R_2$

$\mathcal{E}_1 = 2R_1 + 2(10)$

– Now with new (different) Resistor

abcd: $-I_1R_2 + \mathcal{E} - I_1R_1 = 0$

$\mathcal{E} = I_1R_1 + I_1R_2$

$\mathcal{E}_2 = 3.8R_1 + 3.8(5)$

Since: $\mathcal{E}_1 = \mathcal{E}_2$

$2R_1 + 20 = 3.8R_1 + 19$

$1 = 1.8R_1$

$\boxed{0.556\ \Omega = R_1}$

Now substitute R_1 into either equation

$\mathcal{E}_1 = 2(0.556) + 20$

$\boxed{\mathcal{E}_1 = 21.11\ V}$

2. A copper wire has a cross-sectional area of 5.0 x 10^{-7} m^2 and a length of 10.0 m. An aluminum wire of exactly the same dimensions is welded to the end of the copper wire. the ends of this long copper-aluminum wire are connected to a 3.0-volt battery. Neglect the resistance of any other wires in the figure.

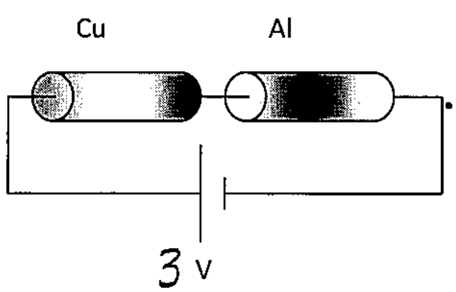


Figure not drawn to scale

Determine
(a) the total resistance of the circuit. 3 pts.
(b) the total current in the wire. 2 pts.

a) $R_{Cu} = \rho \frac{L}{A} = 1.72 \times 10^{-8}\ \Omega \cdot m \times \frac{10\ m}{5 \times 10^{-7}\ m^2}$

$R_{Cu} = 0.344\ \Omega$

$R_{AL} = \rho \frac{L}{A} = 2.83 \times 10^{-8}\ \Omega \cdot m \times \frac{10\ m}{5 \times 10^{-7}\ m^2}$

$R_{AL} = 0.566\ \Omega$

∴ Since in Series = $R_{Cu} + R_{AL} = \boxed{0.9\ \Omega}$

b) $I = \frac{V}{R} = \frac{3\ V}{.9\ \Omega} = \boxed{3.33\ A}$

3. Which of the following wires is likely to have the greatest resistance? 2pts.
   a. A copper wire 0.2 mm thick and 10 cm long
   b. A Nichrome wire 0.2 mm thick and 10 cm long
   c. A Nichrome wire 0.1 mm thick and 15 cm long
   d. A copper wire 0.3 mm thick and 5 cm long.

$R = \rho \frac{L}{A(\pi r^2)}$

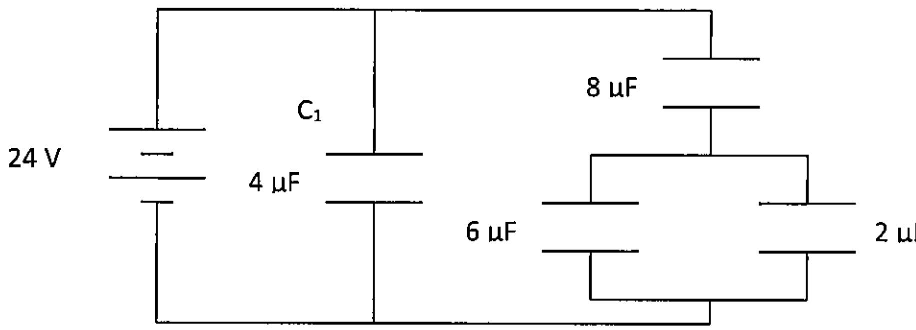
a) $R = \rho \frac{L}{A} = 1.72 \times 10^{-8}\,\Omega \cdot m \times \frac{.1m}{3.14 \cdot (0.0001m)^2} = \frac{1.72 \times 10^{-9}\,\Omega \cdot m^2}{3.14 \times 10^{-8}\,m^2} = 0.0548\,\Omega$

b) $R = \rho \frac{L}{A} = 110 \times 10^{-8}\,\Omega \cdot m \times \frac{.1m}{3.14 \cdot (0.0001)^2} = \frac{1.1 \times 10^{-7}\,\Omega \cdot m^2}{3.14 \times 10^{-8}\,m^2} = 3.5\,\Omega$

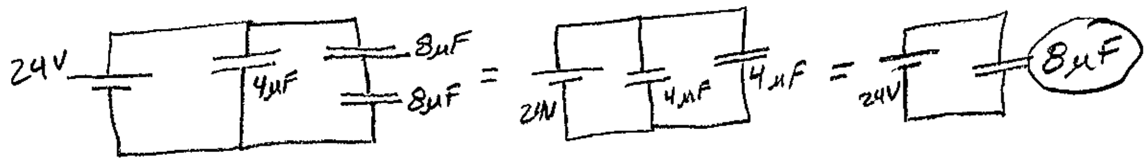
c) $R = \rho \frac{L}{A} = 110 \times 10^{-8}\,\Omega \cdot m \times \frac{.15m}{3.14 \cdot (0.00005)^2} = \frac{1.65 \times 10^{-7}\,\Omega \cdot m^2}{7.85 \times 10^{-9}\,m^2} = \boxed{21.02\,\Omega}$

d) $R = \rho \frac{L}{A} = 1.72 \times 10^{-8}\,\Omega \cdot m \times \frac{.05m}{3.14 \times (0.15)^2} = \frac{8.6 \times 10^{-10}\,\Omega \cdot m^2}{7.065 \times 10^{-2}\,m^2} = 1.22 \times 10^{-8}\,\Omega$

4. In the diagram below, determine the value in each of the below parts of the problem



   a. Find the equivalent capacitance of the capacitors above. 4 pts



   b. Determine the total charge in the circuit. 2 pts.

$Q_T = CV = 8\mu F \cdot 24V = \boxed{192\,\mu C}$

   c. Determine the charge on one plate of C_1. 2 pts.

C_1 is in parallel with the battery so has 24 Volts

$Q_1 = C_1 V = 4\mu F \cdot 24V = 4\mu \frac{C}{J} \cdot 24 \frac{J}{C} = \boxed{96\,\mu C}$

   d. Determine the electrical energy stored in C_1. 2 pts.

$u = \frac{1}{2}\frac{Q^2}{C}$

$u = \frac{1}{2}QV$

$u = \frac{1}{2}CV^2 = \frac{1}{2}\,4\mu \frac{C^2}{J} \times \left(24 \frac{J}{C}\right)^2 = \boxed{1152\,\mu J}$

5. A light bulb oven is left on for 3 hrs and consumes 18 Watt hours of electricity. If the bulb draws a current of 0.3A, what is the resistance of the bulb? 3 pts.

$P = V \cdot I$

$P = I^2 R$

$E = P \cdot t$

$E = I^2 R \cdot t$

$E = 18W \cdot 3Hr \Rightarrow 54 WHr \div 1000 = 0.054 KWH$

$0.054\ KWH = (.3\ \frac{C}{s})^2 \cdot R \cdot 3Hr$

$0.018\ KW = .09\ C^2/s^2 \cdot R$

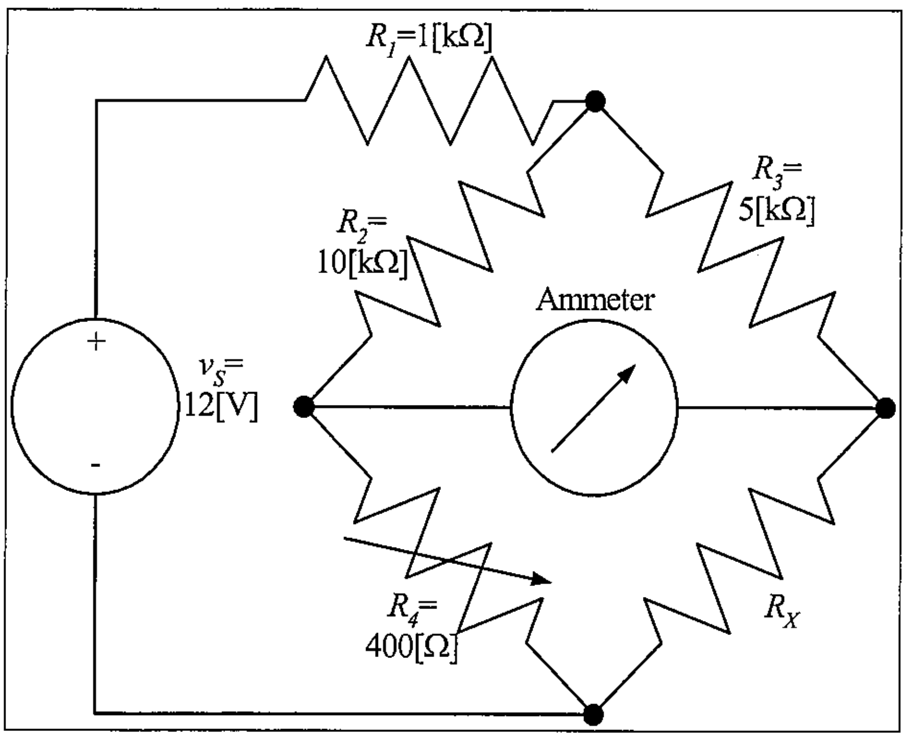
$18\ W = .09\ C^2/s^2 \cdot R$

$\frac{18\ J/s}{.09\ C^2/s^2} = R$

$R = 200\ \frac{J \cdot s}{C^2}$ or $200\ \Omega$

6. The ammeter shown has a meter resistance of 100[Ω]. Resistor R_4 has been adjusted so that the ammeter will read zero. Find the value of R_X for this situation. 5 pts.

BALANCED WHEATSTONE BRIDGE:



$\frac{R_3}{R_2} = \frac{R_x}{R_4}$

$R_2 \cdot R_X = R_3 \cdot R_4$

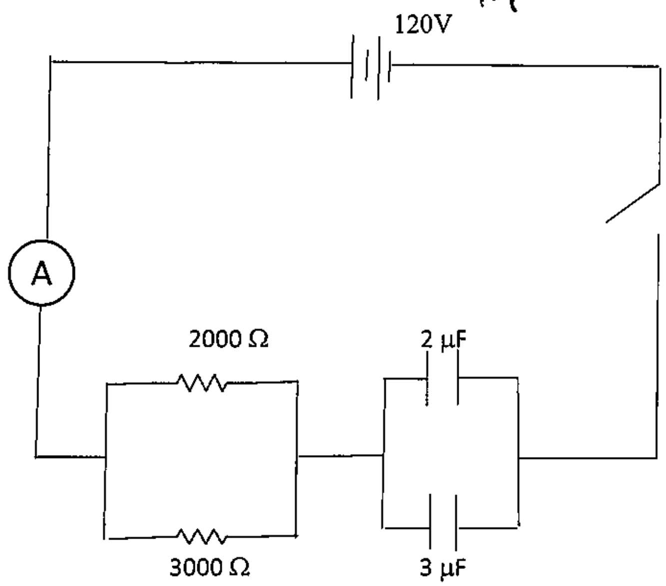
$R_X = \frac{R_3 \cdot R_4}{R_2} = \frac{5000\Omega \cdot 400\Omega}{10{,}000\Omega}$

$R_X = 200\Omega$

Bonus: RC circuit: Show all of your work and label all units. ~~15~~5pts.

*Analyze the circuit below to find the charge stored on each capacitor at steady state. ~~Additionally, find the ammeter reading at 3.0 milliseconds.~~

10pts



2μF: $Q = CV = 2\times10^{-6}F \cdot 120V$

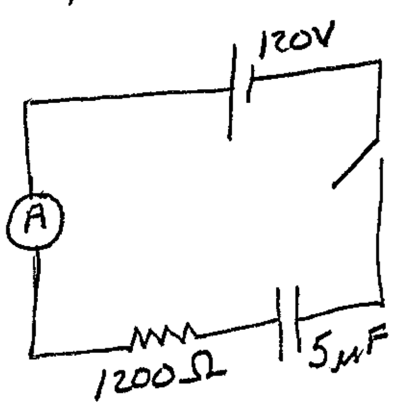
$Q = 2.4\times10^{-4}C$

3μF: $Q = CV = 3\times10^{-6}F \cdot 120V$

$Q = 3.6\times10^{-4}C$

AT "steady STATE" the CAPACITORS ARE FULL, THUS CURRENT STOPS FLOWING. THE VOLTAGE IN THE ABOVE DIAGRAM GIVES 120V to EACH CAPACITOR, BECAUSE THEY ARE IN PARALLEL TO 2μF & 3μF CAPACITOR GET THE SAME VOLTAGE (120V). THE RESISTORS AT "STEADY STATE" DON'T HAVE CURRENT FLOWING, SO NO VOLTAGE DIFFERENCE.

TO FIND CURRENT AT time = 3ms WE NEED TO KNOW MAX CURRENT AND TIME CONSTANT. THE EQUIVALENT RESISTANCE IS 1200Ω & CAPACITANCE IS 5μF.



$I_{max} = \frac{V}{R} = \frac{120V}{1200\Omega} = 0.1A$

$T = RC = 1200\Omega \cdot 5\times10^{-6}F = 0.006sec$

$I = I_{max}e^{-t/RC} = .1(e^{-0.003/0.006}) = 0.061A$