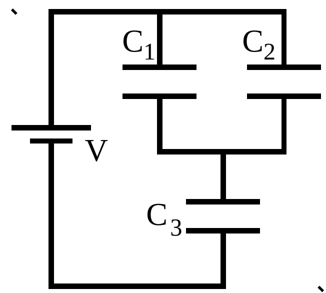
Name:____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. In the circuit at the right, the battery voltage is 30.0V. Find (a)the equivalent capacitance, (b)the total charge that flows through the battery (c)the charge on each capacitor and (d)the potential difference for each capacitor (C_1=40.0μF, C_2=80.0μF, and C_3=60.0μF).



Q(μC)	C(μF)	V(V)
400	40.0	10.0
800	80.0	10.0
1200	60.0	20.0
1200	battery	30.0

(a) C_1 and C_2 are in parallel so,

$$C_p = C_1 + C_2 = 120\mu F$$

This capacitance is in series with c3,

$$\frac{1}{C_{eq}} = \frac{1}{C_p} + \frac{1}{C_3} \qquad C_{eq} = \frac{C_p C_3}{C_p + C_3} = \underline{\underline{40.0\mu F}}$$

(b)Using the definition of capacitance,

$$C \equiv \frac{Q}{V} \qquad Q = CV = (40)(30) = \underline{\underline{1200\mu C}}$$

(c)C_3 is in series with the battery so it's charge is the same as the battery, Q_3=1200μC. The voltage on C_3 is,

$$V_3 = \frac{Q_3}{C_3} = \frac{1200}{60} = 20.0V$$

This leaves 10.0V for each of C_1 and C_2 since they are in parallel. The charge on these is,
$Q_1 = C_1 V_1 = (40)(10) = 400\mu C$ and $Q_2 = C_2 V_2 = (80)(10) = 800\mu C$.

2. Explain how a dielectric material between the plates of a capaxitor will increase the capacitance.

The alignment of the dipoles in the dielectric creates an electric field that is opposite to the field created by the charges on the capacitor plate. The resulting total field is less than without the dielectric. The smaller field means that the potential difference is smaller for the same amount of charge. Therefor, the capacitance is larger (more charge for less voltage).

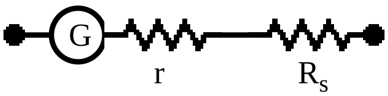
3. Some material scientists studying a new compound wish to find its resistivity. They take a cube 1.00cm on a side and apply a 1.50V potential difference between opposite faces. They measure the resulting current to be 450mA. Find the resistivity of the compound.

The definition of resistance is $R = \rho\frac{\ell}{A}$.

If each side of the cube is a, then ℓ=a and A=a^2 and $R = \rho\frac{a}{a^2} = \frac{\rho}{a}$ $\quad \rho = aR$

Ohm's Rule $V = IR$ $\quad R = \frac{V}{I}$ and substituting $\rho = a\frac{V}{I} = (0.01)\frac{1.50}{0.450} = \underline{\underline{0.0333\Omega\ m}}$.

4. A galvanometer has a coil resistance of 100Ω and reads full scale when the current through it is 5.00mA. Add a resistor to this galvanometer to build a voltmeter that reads up to 120V. Sketch the circuit of the voltmeter.

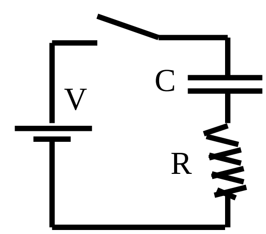


$r = 50.0\Omega$

Using Ohm's Rule $V = IR$ where the total resistance of the two resistors in series is $R = r + R_s$.

Solving for R_s, $V = IR = I(r + R_s)$ $\quad R_s = \frac{V - Ir}{I} = \frac{120 - (0.005)(100)}{0.005} = \underline{\underline{23.9k\Omega}}$

5. A 10.0MΩ resistor is in series with a 10.0μF capacitor and a 1.50V battery as shown at the right. Find the current through the resistor and the charge on the capacitor (a)just after the switch is closed, (b)100s after the switch is closed and (c)two hours after the switch is closed.



(a)Just as the switch is closed, there is <u>no charge on the capacitor</u> so there is no voltage on the capacitor. Therefor, all the voltage must be on the resistor. Using Ohm's Rule,

$$V = IR \qquad I = \frac{V}{R} = \frac{1.5}{10.0M} = \underline{\underline{0.150\mu A}}$$

(b)For a charging capacitor,

$$q = CV\left(1 - e^{-t/RC}\right) = (10.0\mu)(1.50)\left(1 - e^{-\frac{100s}{(10M)(10\mu)}}\right) = 15.0\mu C\left(1 - e^{-1}\right) = \underline{\underline{9.48\mu C}}$$

The voltage on the capacitor is $V_C = \frac{q}{C} = \frac{9.48\mu}{10.0\mu} = 0.948V$ which leaves the resistor with 1.50 - 0.948 = 0.552V.

Using Ohm's Rule,

$$V = IR \qquad I = \frac{V}{R} = \frac{0.552}{10.0M} = \underline{\underline{0.0552\mu A}}$$

(c)After a long time the capacitor is fully charged so $q = CV = (10.0\mu)(1.50) = \underline{\underline{15.0\mu C}}$. This leaves no voltage for the resistor so the <u>current must be zero</u>.