Circuits/Electromagnetics

AP Physics – Mr. Hall

WORKSHEET #3

Name: ______________________

1. A television set draws 2.55 A when operated on 120 V. (a) What is the resistance of the set? (b) How much power does the set use? (c) If the set is operated for 5.0 hours per day, what energy in kWh (kilowatt hour) does it consume in one month (30.0 days). (d) At $ 0.055 per kWh, what is the cost of operating the set for the one month time period?

a. R = V/I = 120 V/2.55 A = 47.05882 Ω = **47 Ω**

b. P = VI = 120 V · 2.55 A = 306 W = **310 W**

c. E = P · t = 0.306 kW · 5.0 hr/day · 30.0 days = 45.9 kWh = **46 kWh**

d. cost = E · rate = 45.9 kWh · $0.055/kWh = $2.5245 = **$2.52**

2. A 2.50 pF capacitor is connected to a 12.0 V battery. What is the charge on the capacitor?

$Q = CV = 2.50\times10^{-12}\ \text{F} \cdot 12.0\ \text{V} =$ $\boxed{3.00\times10^{-11}\ \text{C or } 30.0\ \text{pC}}$

3. A parallel plate capacitor has an area of 1.90 cm^2. Plate separation is 0.0850 mm. What is its capacitance?

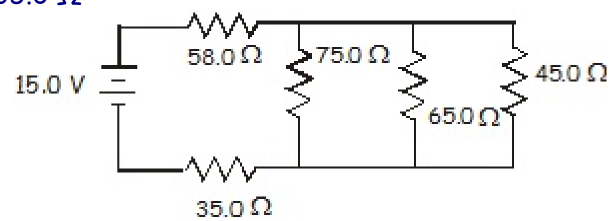
$C = \varepsilon_0 A/d = 8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2 \cdot 1.90\times10^{-4}\ \text{m}^2/8.50\times10^{-5}\ \text{m}$

$= 1.978235\times10^{-11}\ \text{F} =$ $\boxed{1.98\times10^{-11}\ \text{F or } 19.8\ \text{pF}}$

4. 112.5 μF capacitor connected across 9.00 V battery. Find the potential energy stored in the capacitor.

$U_C = \frac{1}{2} CV^2 = 0.5 \cdot 112.5\times10^{-6}\ \text{F} \cdot (9.00\ \text{V})^2 = 0.00455625\ \text{J} =$ $\boxed{0.00456\ \text{J or } 4.56\ \text{mJ}}$

5. Given this lovely circuit: (a) Find the equivalent resistance for this circuit. (b) Find the current supplied by the battery. (c) Find the current through the 65.0 Ω resistor.



a. $R_{tot} = 58.0\ \Omega + ((75.0\ \Omega)^{-1} + (65.0\ \Omega)^{-1} + (45.0\ \Omega)^{-1})^{-1} + 35.0\ \Omega$
$= 112.6308725\ \Omega =$ $\boxed{113\ \Omega}$

b. $I = V/R = 15.0\ V / 112.6308725\ \Omega$
$= 0.1331784054\ A =$ $\boxed{0.133\ A \text{ or } 133\ mA}$

c. $V_{65\Omega} = 15.0\ V - (58.0\ \Omega + 35.0\ \Omega) \cdot 0.1331784054\ A$
$= 2.614408295\ V$
$I_{65\ \Omega} = V_{65\ \Omega}/R = 2.614408295\ V/65.0\ \Omega$
$= 0.0402216661\ A =$ $\boxed{0.0402\ A \text{ or } 40.2\ mA}$

6. An electron is accelerated from rest through a potential difference of 9.0 V. Find (a) the energy of the particle, and (b) the speed of the particle.

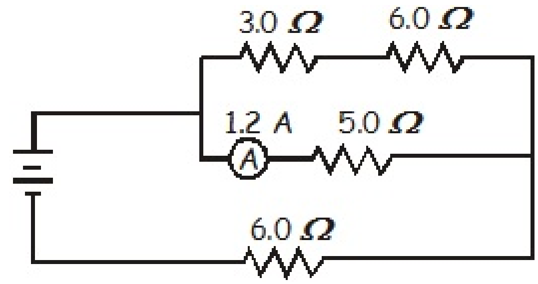
a. $U_E = qV = 1.60\times10^{-19}\ C \cdot 9.0\ V =$ $\boxed{1.44\times10^{-18}\ J \text{ or } 1.44\ aJ}$

b. $KE = \frac{1}{2}mv^2$
$v = (2KE/m)^{\frac{1}{2}} = (2 \cdot 1.44\times10^{-18}\ J/9.11\times10^{-31}\ kg)^{\frac{1}{2}} = 1778021.693\ m/s =$ $\boxed{1.78\times10^{6}\ m/s}$

7. A battery is rated at 9.00 V. It delivers a current of 117 mA when connected to a 75.0 Ω load. Find the internal resistance of the battery.

$V_{circuit} = 75.0\ \Omega \cdot 0.117\ A = 8.775\ V$
$R_{bat} = (9.00\ V - 8.775\ V) / 0.117\ A = 1.923076923\ \Omega =$ $\boxed{1.92\ \Omega}$

8. Find the electric potential of the battery.



$V_{5.0\,\Omega} = RI = 5.0\ \Omega \cdot 1.2\ A = 6.0\ V$

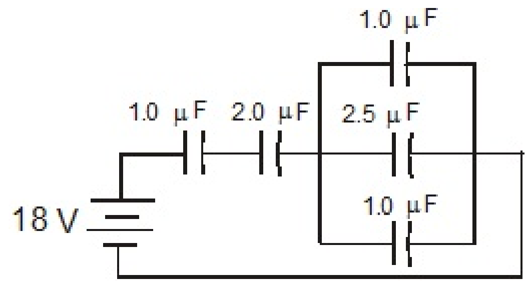
$I_{3.0 + 6.0\,\Omega} = V/R = 6.0\ V/9.0\ \Omega = 0.666667\ A$

$I_{6.0\,\Omega} = 1.2\ A + 0.666667\ A = 1.866667\ A$

$V_{6.0\,\Omega} = RI = 6.0\ \Omega \cdot 1.866667\ A = 11.2\ V$

$V_{bat} = V_{5.0\,\Omega} + V_{6.0\,\Omega} = 6.0\ V + 11.2\ V = \boxed{17.2\ V}$

9. The battery is connected to the circuit for a long time so that all the capacitors are fully charged up. Find (a) the total capacitance for this circuit and (b) the charge stored on the 2.5 μF capacitor.



a. $C_T = ((C_1 + C_{2.5} + C_1)^{-1} + C_2^{-1} + C_1^{-1})^{-1}$

$= 0.5806451613\ \mu F = \boxed{0.58\ \mu F}$

b. $Q = C_T V = 0.5806451613\ \mu F \cdot 18\ V$

$= 10.4516129\ \mu C$

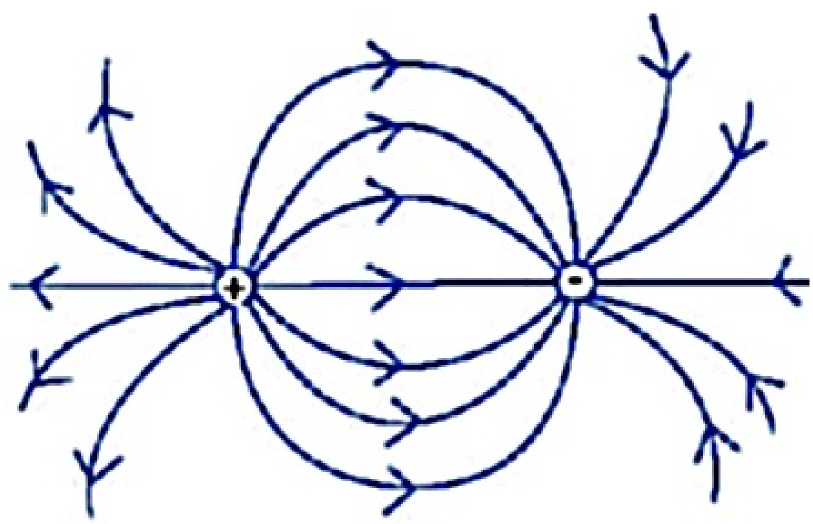
$V_{1+2.5+1} = Q/C = 10.4516129\ \mu C/4.5\ \mu F$

$= 2.322580645\ V$

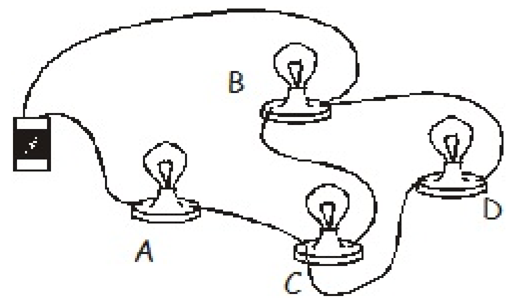
$Q_{2.5} = CV = 2.5\ \mu F \cdot 2.322580645\ V$

$= 5.806451613\ \mu C = \boxed{5.81\ \mu C}$

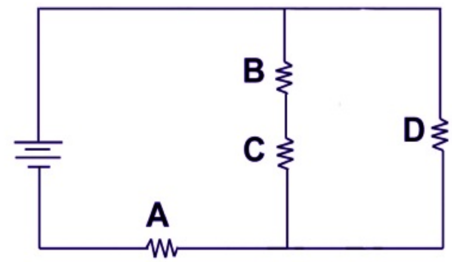
10. Draw in the lines of force between the two identical charges as shown below.



11. In this circuit, A, B, C, and D are identical light bulbs. Assume the battery maintains a constant potential difference between its terminals (the internal resistance of the battery is assumed to be negligible) and the resistance of each light bulb stays constant.



a. Draw a diagram of the circuit using the appropriate symbols.
b. List the bulbs in order of brightness, from brightest to least bright. If any two bulbs have the same brightness, state which ones. Justify your answers.
c. Describe the change in brightness, if any, of bulb A when bulb D is removed from its socket. Justify your answer.
d. Describe the change in brightness, if any, of bulb B when bulb D is removed from its socket. Justify your answer.



a. See diagram on the right ->
b. Brightest to least bright: A, D, B/C (B & C are same). B and C are in the same branch, so they both have the same current. Since they both have the same resistance, they have the same power/brightness as each other. B/C has the same voltage drop as D, and since it has twice the resistance, there will be less current through B/C than through D. Since B and C share a voltage drop equal to D, they'll each have less voltage than D as well. With less current AND less voltage than D, they'll both be dimmer than D. BCD has an equivalent resistance of 2/3 A. This means the voltage drop across BCD is 2/3 the voltage across A. Since the currents for both BC and D add together to make current for A, this means D has 2/3 voltage of A and less current, making it dimmer than A.
c. A will be dimmer if D is removed. If D is removed, then the equivalent resistance in the circuit changes to 3 times A rather than 1 and 2/3 times A. Increased total resistance means less current will flow through the circuit, making A dimmer.
d. B will be brighter if D is removed. If D is removed, B will have 5/3 more current and voltage than it had previously.