Quiz 3 solutions

May 10, 2012

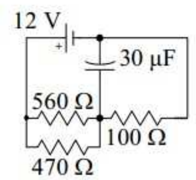

Figure 1

Figure 2

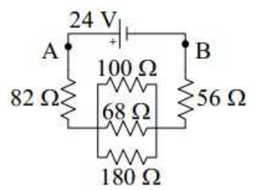

Figure 3

1. In a cathod ray tube, the electron beam current is 30. micro-A. How many electrons hit the tube screen every 40. s?
7.5e15
The total charge is:

$$Q = I \times t = 30 \times 10^{-6}A \times 40s = 1.2 \times 10^{-3}C.$$

So the number of electrons is:

$$\frac{Q}{e} = \frac{1.2 \times 10^{-3}C}{1.6 \times 10^{-19}C} = 7.5 \times 10^{15}.$$

2. (See figure 1) In steady state, what is the current through the capacitor, in amperes?
0
Because the circuit is in steady state, it means the capacitor is fully charged and there is no current through it.
3. A 1.5 V D-cell can deliver 6.0 A for one hour. How much energy does it deliver in that time, in J?
32000

$$W = P \times t = V \times I \times t = 1.5V \times 6A \times 3600s = 32400J$$

4. The current in a 10 ohm resistor increases linearly in time from 0 to 5.0 A in 2.0 s. How much charge passes through the resistor in that time, in C?
5
First we can get the expression of current I as a function of time t:

$$I(t) = 2.5t,$$

where t is in s and I is in A. Then we can get the total charge:

$$Q = \int_0^2 I(t)dt = \int_0^2 2.5tdt = 2.5 \times 2 = 5(C).$$

5. A 100. W white light bulb operates from a 120 V source, as intended. The source is decreased to 100. V, and the bulb looks orange. The resistance of the bulb is constant. What power does it now put out, in W?
69
Let $P_1 = 100W$, $V_1 = 120V$, $V_2 = 100V$, now we need to solve for P_2. We know that $P_1 = \frac{V_1^2}{R}$ and that $P_2 = \frac{V_2^2}{R}$, so if we divide these two equations on both sides, then we can get $\frac{P_1}{P_2} = (\frac{V_1}{V_2})^2$, which indicates

$$P_2 = P_1(\frac{V_2}{V_1})^2 = 100W \times (\frac{100V}{120V})^2 = 69.4W$$

6. (See figure 3) How does the current at A compare to the current at B?
same
They are in series so they have the same current.
7. $R_1 = 50.$ ohms, $R_2 = 100.$ ohms. They are in series carrying current. What is the ratio of powers dissipated, R_1/R_2?
1/2
Because they are in series, they have the same current I.

$$\frac{P_1}{P_2} = \frac{I^2 R_1}{I^2 R_2} = \frac{R_1}{R_2} = \frac{50\Omega}{100\Omega} = \frac{1}{2}$$

8. A 1.0 micro-F capacitor is in parallel with a 2.0 micro-F capacitor. A 3.0 V battery fully charges the combination of capacitors. What is the total energy stored, in J?
1.4e-5
Because they are in parallel, the total capacitance is

$$C = C_1 + C_2 = 10^{-6}F + 2 \times 10^{-6}F = 3 \times 10^{-6}F.$$

So the total energy stored in those two capacitors is

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 3 \times 10^{-6}F \times (3V)^2 = 1.35 \times 10^{-5}J.$$

9. A 75 W bulb operates from a 120 V source, as intended. What is its resistance, in ohms?
190
From $P = \frac{V^2}{R}$, we have

$$R = \frac{V^2}{P} = \frac{(120V)^2}{75W} = 192\Omega.$$

10. (See figure 2) A bound NaOH molecule is modeled as Na+ bound to O(-2) bound to H+, in a straight line in that order. The Na+ ion is 2.0e-10 m from the O(-2), which is 2.0e-10 m from the H+. How much energy does it take to remove the Na+ ion from the molecule (i.e., take it to far away), in J?
1.7e-18
The initial electric potential energy of Na+ is:

$$U_i = k_e \frac{-2 \times 1.6 \times 10^{-19}C \times 1.6 \times 10^{-19}C}{2 \times 10^{-10}m} + k_e \frac{1.6 \times 10^{-19}C \times 1.6 \times 10^{-19}C}{4 \times 10^{-10}m} = -1.7 \times 10^{-18}J$$

To take them far apart, which means the final electric potential energy of Na+ U_f is zero, we need to do work $W = 1.7 \times 10^{-18}J$. It is from the energy conservation(The work you do to separate them transforms into electric potential energy):

$$U_i + W = U_f$$