10B Class Work

This is a classwork given to 10B students on March 11. Since a lot of you may not have had the chance to work on the given assignment and since it wasn't given to the other sections, I will be posting the questions and solutions on here.

Questions

Problem 1 *A photographic flash unit has a 100µF capacitor which is charged up by a small 22.5V battery. How much energy may be discharged into the flash bulb?*

Explanation. *Recall that the energy stored in a capacitor is given by*

$$E = \frac{1}{2}QV, \textit{But, we know that Q=CV, then putting CV in place of Q, we get} \tag{1}$$

$$E = \frac{1}{2}CV^2 \tag{2}$$

Therefore, plugging our given values into equation (2), we get:

$$E = \frac{1}{2}100\mu\text{F}(22.5V)^2 \tag{3}$$

$$E = 25312.5\mu J \tag{4}$$

$$E = 0.0253J \tag{5}$$

Problem 2 *Find an expression for the resultant capacitance of 4 equal capacitance capacitors connected in series.*

Explanation. *To do this problem, recall that in a series circuit, the reciprocal of the net capacitance is the reciprocal sum of each capacitance, that is*

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4} \tag{6}$$

$$\textit{We know that } C_1 = C_2 = C_3 = C_4 = C, \textit{ Therefore, our equation becomes} \tag{7}$$

$$\frac{1}{C_T} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} \tag{8}$$

Learning outcomes:

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Then, we add the fractions as we normally would(Since they all have the same denominator, we do the following)

$$\frac{1}{C_T} = \frac{4}{C} \text{ Then, we cross multiply to get } C_T \tag{9}$$

$$C_T = \frac{C}{4} \tag{10}$$

Problem 3 *You want to make a 5.0µF capacitor, what area plates are required if the permissivity of the dielectric between the plates is* $\varepsilon = 7.1 X 10^{-11}$ *and the separation between them is 0.4mm.*

Explanation. *To do this problem, recall that the capacitance of a circuit is affected by the Area of the plates(A), the separation between them(d) and the type of the dielectric in them. This relationship is given by:*

$$C = \frac{\varepsilon A}{d} \text{ Rearranging the terms, we get} \tag{11}$$

$$A = \frac{Cd}{\varepsilon} \text{ Then, we put the given terms and evaualte the equation} \tag{12}$$

$$A = \frac{(5.0\mu\text{F})(0\,4\text{mm})}{7.1X10^{-11}\frac{F}{m}} \tag{13}$$

To simplify the above math, convert everything to SI units, we then get

$$A = 2817m^2 \tag{14}$$

Problem 4 *Find the relative permissivity of the dielectric above.*

Explanation. *To do this problem, we have to understand the concept of relative permissivity. Relative perimissivity or dielectric constant is the ratio between the permissivity of a dielectric(*ε*) to the permissivity of free space(*ε_0*). Mathematically, it is given as follows.*

$$\kappa = \frac{\varepsilon}{\varepsilon_0} \text{ Then, evaluate using the values} \tag{15}$$

$$\kappa = \frac{7.1X10^{-11}\frac{F}{m}}{8.85X10^{-11}\frac{F}{m}} \tag{16}$$

$$\kappa = 8.02 \tag{17}$$

Problem 5 *If there are **n** number of equal-capacitance capacitors, what is the effective capacitance when the capacitors are connected in series and in parallel?*

Explanation. *When the capacitors are connected in series, we know that the reciprocal of the effective capacitance is the sum of the reciprocal of each capacitance(Refer to question 4)*

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4} + ... + \frac{1}{C_n} \quad (18)$$

We know that

$$\frac{1}{C_T} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + ... + \frac{1}{C} \quad (19)$$

We know that $C_1 = C_2 = C_3 = C_4... = ...C_n = C$, *Therefore, our equation becomes* (20)

*Since we have **n** number of capacitors, our equation becomes:*

$$\frac{1}{C_T} = \frac{n}{C} \quad (21)$$

$$C_T = \frac{C}{n} \text{ When you cross multiply, you get the } C_T \text{ term alone} \quad (22)$$

To visualize this problem, do the problem when there are 2,3,4, and 5 capacitors in a circuit. Each time, you will find that the net capacitance will be $\frac{C}{2}$, $\frac{C}{3}$, $\frac{C}{4}$, *and* $\frac{C}{5}$ *respectively. See a pattern?*

Explanation. *When the capacitors are connected in parallel, we know that the effective capacitance is the algebraic sum of each capacitance. That is,*

$$C_T = C_1 + C_2 + C_3 + C_4 + ... + C_n \quad (23)$$

$$\text{Since } C_1 = C_2 = C_3 = C_4 = ... = C_n, \quad (24)$$

$C_T = C+C+C+C+...+C$ *Since we have n number of these capacitors, we will have* C_T *become* (25)

$$C_T = nC \quad (26)$$

To visualize this problem, do the problem when there are 2,3,4, and 5 capacitors in a circuit. Each time, you will find that the net capacitance will be 2C, 3C, 4C, and 5C respectively. See a pattern?