Six problems from Serway...make sure you do the problems, not the questions!

The first five problems are worth 3 points each.

* The last problem is extra credit, worth 5 points!

Due at 23:59, Friday, 8 February 2008.

1 Serway, Problem 26.37

SOLUTION

The capacitance is given by

$$C = \frac{\kappa\epsilon_0 A}{d} \tag{1}$$

$$= \frac{(2.1)(8.85\times10^{-12})(0.000175)}{4\times10^{-5}} \tag{2}$$

$$= \boxed{81.3\text{ pF}}. \tag{3}$$

The maximum potential difference or breakdown voltage is related to the dielectric strength by

$$\Delta V_{\text{max}} = E_{\text{max}} d \tag{4}$$

$$= (6\times10^{7})(4\times10^{-5}) \tag{5}$$

$$= \boxed{2400\text{ V}}. \tag{6}$$

2 Serway, Problem 26.41

SOLUTION

The total breakdown voltage will be the sum of the voltages across all three series elements at the lowest breakdown voltage in the series, namely 15 V for the lone 10 μF capacitor:

$$\Delta V_{\text{max,tot}} = 2\Delta V_{\parallel} + 15. \tag{7}$$

The potential difference $\Delta V_{\parallel}$ across the 20 μF capacitors in parallel when 15 V is applied across the 10 μF capacitor is given by

$$\Delta V_{\parallel} = \frac{Q_{\text{max},10\mu}}{2\times20\mu} = \frac{(10\mu)(15)}{2\times20\mu} = 3.75, \tag{8}$$

thus

$$\Delta V_{\mathsf{max,tot}} = 2 \times 3.75 + 15 = \boxed{22.5\ \mathrm{V}}. \tag{9}$$

3 Serway, Problem 26.51

SOLUTION

The area is given by

$$A = \frac{Cd}{\kappa\epsilon_0} \tag{10}$$

$$= \frac{C\Delta V_{\mathsf{max}}}{\kappa\epsilon_0 E_{\mathsf{max}}} \tag{11}$$

$$= \frac{(2.5 \times 10^{-7})(4000)}{(3.00)(8.9 \times 10^{-12})(2 \times 10^8)} \tag{12}$$

$$= \boxed{0.19\ \mathrm{m}^2}. \tag{13}$$

4 Serway, Problem 26.59

SOLUTION

At 100 V, the charge on the capacitor is

$$Q = C\Delta V = 100C. \tag{14}$$

That charge is then distributed between two capacitors in parallel: C and 10 μ. The equivalent capacitance is

$$C_{\mathsf{eq}} = C + 10\ \mu = \frac{100C}{30}. \tag{15}$$

Solving for C, we have

$$C = \boxed{4.29\ \mu\mathrm{F}}. \tag{16}$$

5 Serway, Problem 26.61

SOLUTION

The original energy is given by

$$U_0 = \frac{1}{2}C_0(\Delta V)^2, \tag{17}$$

and the final by

$$U = \frac{1}{2}\kappa C_0(\Delta V)^2, \tag{18}$$

so

$$\frac{U}{U_0} = \kappa. \tag{19}$$

Likewise, the charge increases by a factor κ.

6 Serway, Problem 26.65*

SOLUTION

The key to this problem is recognizing that the charges on the right-hand plates of the first parallel combination of capacitors are drawn from the left-hand plates of the second parallel combination *and* the plates of the central capacitor. Since equal charge is drawn from equal reservoirs on both sides, there is no potential difference, and therefore equal and *like* charges on the plates of the central capacitor. In other words, it does not act like a capacitor at all, but rather an open circuit (or, equivalently in this case, a short). Thus, the equivalent capacitance is simply the parallel combination of the two series:

$$C_{\text{eq}} = 2\frac{2C^2}{3C} = \boxed{\frac{4}{3}C}. \tag{20}$$