Name______________________________Pd________

Capacitor Calculations

1. A capacitor is made of thin metal plates with a length of 7.7 m and a width of 2.5 cm. There is a sheet of thin plastic between the plates made of polyethylene (κ=2.25 (instead of air's κ=1)) that has a thickness of 0.5 mm. What is the capacitance?

   $C = \kappa\varepsilon_0 A/d = 2.25(8.85\cdot10^{-12})(7.7)(0.025)/(0.0005)$

   $C = 7.67$ nF [NOTE: Capacitances are usually given in micro-, nano-, or pico- farads]

2. For the capacitor above, what is the charge on one of the parallel plates when the voltage across the plates is 9 V?

   $Q = VC = 9(7.67\cdot10^{-9})$

   $Q = 6.9\cdot10^{-8}$ C [NOTE: Don't confuse the unit of Coulombs with the variable for Capacitance!]

3. What would be the effect on your answer to problems 1 & 2 if the plastic were replaced by water (κ=80)?

   The capacitance would increase by 35.6 times.

   The charge held on the capacitor would also increase by 35.6 times.

4. What might be the problem with replacing the polyethylene with water in the practical construction of such a capacitor?

   If the water wasn't pure, it might act as a poor conductor.

   The water might corrode any container it was held in.

   If the capacitor overheats from a high energy storage due to high potentials, the water might boil and cause a small explosion of hot liquid.

5. How much energy is stored by a 33μF capacitor that holds a charge of 3.96 mC on each plate?

   $V = Q/C = (3.96\cdot10^{-3})/(33\cdot10^{-6}) = 120$ V

   $E_{PE} = ½\,QV = 0.5(3.96\cdot10^{-3})(120)$

   $E_{PE} = 0.24$ J

6. A 1000 μF capacitor, with a wax paper coated dielectric, is placed across the terminals of a 12 V battery. How much charge flows from the battery to the capacitor?

   $Q = VC = (12)/(1000\cdot10^{-6})$

   $Q = 0.012$ C

7. If you triple the potential difference between the plates of a capacitor, what will happen to the capacitance? Nothing, capacitance doesn't change without physically altering the capacitor

   What will happen to the amount of charge stored? It will triple

8. A capacitor manufacturing company, ElectroCo, states the following in their catalog: "Our capacitors are more expensive than RobCo's because we use thicker gold plates in our capacitors. RobCo uses thin aluminum foil." They go on to state that their capacitors are the same in every other way. Would you buy an ElectroCo 33μF capacitor for $4.33 each, or would a RobCo 33μF capacitor at 2¢ per dozen be just as good? Explain. The RobCo aluminum capacitor is just as good. They are the same capacitance, which is what capacitors are purchased for. Gold is a very slightly better conductor than aluminum, but that would make little difference in the charging time for either capacitor. The extra thickness of the gold plates would probably negate any faster charging time due to the metal choice.

__C__ 9. A dielectric ____ the amount of charge stored by a capacitor because the electric field between the plates of the capacitor is ____.

   A. increases; strengthened B. decreases; strengthened

   C. increases; weakened D. decreases; weakened

10. An air-separated capacitor is made with aluminum foil separated by a thickness of 0.3 mm. It is connected to a voltage source that provides a potential difference of 23 V across the gap. It stores 1.2 mJ when fully charged. What is the area of a plate, and how much charge does each plate hold? How many sheets of 8.5x11" paper would have the same area?

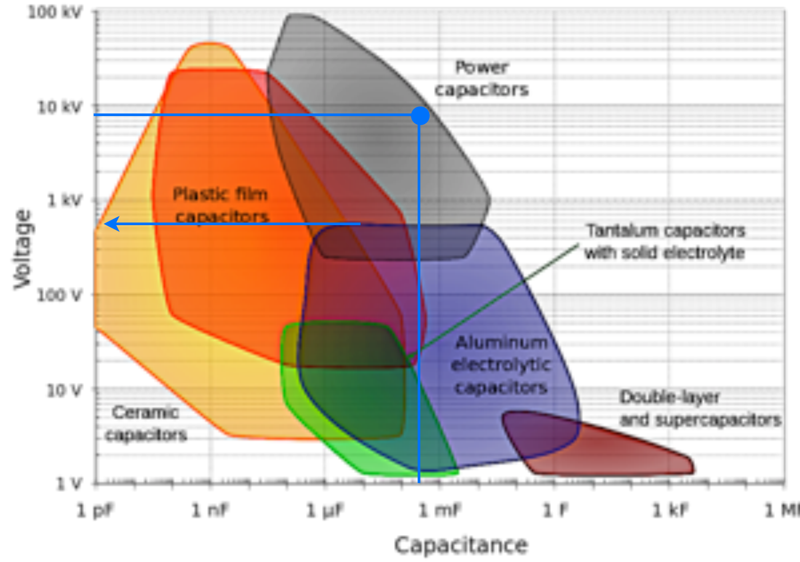
    $E_{PE} = 1.2\cdot10^{-3} = ½\,QV = 0.5(Q)(23)$ $Q = 1.04\cdot10^{-4}$ C

    $A = Cd/\kappa\varepsilon_0 = Qd/V\kappa\varepsilon_0 = (1.04\cdot10^{-4})(0.0003)/(23)(1)(8.85\cdot10^{-12})$

    $A = 153.3\ m^2$ Area of one sheet = 92 in^2 = 0.0594 m^2, so the area would be the equivalent of about 2583 sheets of paper.

11. A lot of textbooks state that capacitors store charge. It's more correct to say that they store ____energy____ due to the electric field between their plates, since some charge move onto one plate, but leaves the other.

12. A capacitor is made so that it has two plates with individual areas of 2 m^2 with a separation of 1 micron and a dielectric with $\kappa=20$. If the energy stored in the capacitor when hooked up across a certain voltage source is 11300 J…



a) What is the capacitance of the capacitor?

$C = \kappa\varepsilon_0 A/d = 20(8.85\cdot10^{-12})(2)/(1\cdot10^{-6})$

$C = 354\ \mu F$ $(3.54\cdot10^{-4}\ F)$

b) What is the voltage of the source?

$E_{PE} = \frac{1}{2}CV^2 = 11300 = 0.5(354\cdot10^{-6})(V^2)$

$V = 7990\ V$

c) Using the graph at right, identify the type of capacitor being used.

Power capacitor

d) Draw a dot showing the measurements for this particular capacitor on the chart.

13. At 100 pF and 10 V, a ceramic capacitor holds how much charge?

$Q = VC = (10)(100\cdot10^{-12})$

$Q = 1\cdot10^{-9}\ C$ (1 nC)

14. How much energy does a 1 mF aluminum electrolytic capacitor store at its highest voltage?

The highest voltage for an aluminum electrolytic capacitor is about 600 V (as shown by the arrow).

$E_{PE} = \frac{1}{2}CV^2 = 0.5(1\cdot10^{-3})(600)^2$

$E_{PE} = 180\ J$