## Problem 1

University Physics, problem 75

Three square metal plates A, B, and C each 12.0 on a side and 1.5 mm thick, are arranged as in the figure in the book. The plates are separated by sheets of paper 0.45 mm thick and with dielectric constant 4.2. The outer plates are connected together and connected to point b. The inner plate is connected to point a.

   a. Show the charge distribution on the plates if a is maintained at a positive potential with respect to b.

   b. What is the capacitance between points a and b?
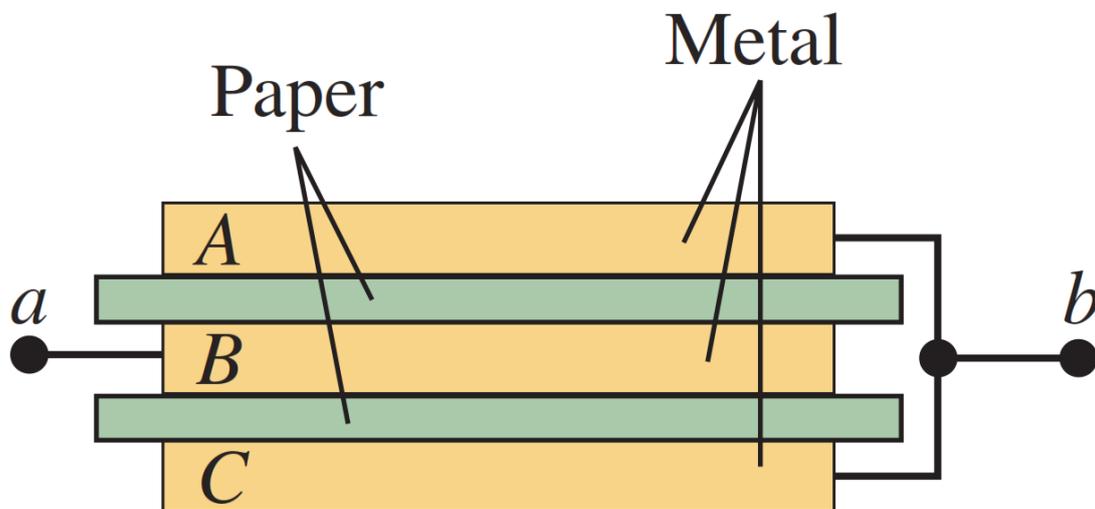
Solution

Part (a)

Since plate B is connected to the point at a higher potential, then it has a positive charge and plates A and C are negatively charged.

Part (b)

This setup is just like 2 identical capacitors in parallel. $C_{eq} = C_1 + C_2 = 2C$

$$C_e q = 2\frac{\epsilon A}{d} = 2\frac{\epsilon_0 \epsilon_r A}{d} = 2\frac{\epsilon_0 \cdot 4.212^2 \times 10^{-4}}{0.45 \times 10^{-3}} = 2.38 \times 10^{-9} F$$

Note: The thickness of the plates is redundant. I do not know why it's given in the problem.

Problem 2

University Physics, problem 60 (exam problem)

The capacitors in the figure in the book are initially uncharged and are connected, as in the diagram, with switch S open. The applied potential difference is $V_{ab} = 210$ V

a. What is the potential difference V_{cd}?

b. What is the potential difference across each capacitor after switch is closed?

c. How much charge flowed through the switch when it was closed?
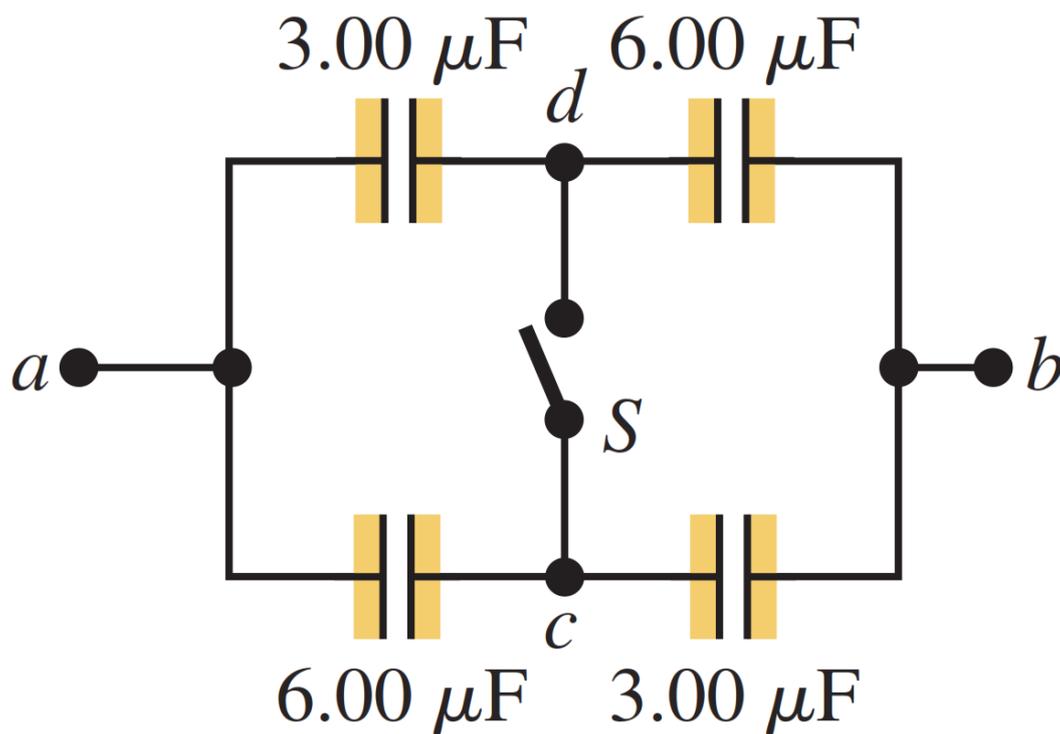
Part (a)

To solve this, we should first find the charges on each capacitor. The two branches are identical. The two capacitors in each branch are in series so they have the same charge. This means that all the four capacitors have the same charge, which is half the charge on the equivalent capacitor.

$C_{eq} = 2(1/3 + 1/6)^{-1} = 4\mu F$

$Q = VC_{eq}/2 = 0.5 \cdot 4 \times 10{-6} \times 210 = 4.2 \times 10^{-4}$ C

$V_c = 210 - \dfrac{4.2 \times 10^{-4}}{6 \times 10^{-6}} = 140$ V

$V_d = 210 - \dfrac{4.2 \times 10^{-4}}{3 \times 10^{-6}} = 70$ V

$V_{cd} = V_c - V_d = 140 - 70 = 70$ V

Part (b)

When the switch is closed, every 3/6 combination of capacitors are together in parallel, and the two combinations are together in series. Each 3/6 are together in parallel thus have the same voltage, and due to symmetry, the other 3/6 will also have the same voltage. By Symmetry, the voltage on each capacitor is $V = 210/2 = 105$ V

Part (c)

The charge that flows through the switch is just the difference between the charges on the 3 and 6 capacitors. This can easily be proved by taking an isolated island which includes the switch as well as the positive plate of one capacitor and the negative plate of another. Try to formally prove it yourself!

$Q_3 = 3 \times 10^{-6} \times 105 = 3.15 \times 10^{-4}$ C

$Q_6 = 3 \times 10^{-6} \times 105 = 6.3 \times 10^{-4}$ C

$Q_S = Q_6 - Q_3 = 3.15 \times 10^{-4}$ C