LESSON 8

BOOK CHAPTER 25

CAPACITANCE

Capacitors in series combination:

Potential difference of each actual capacitor:

$$V_1 = \frac{q}{C_1} \qquad V_2 = \frac{q}{C_2} \qquad \text{And} \qquad V_3 = \frac{q}{C_3}$$

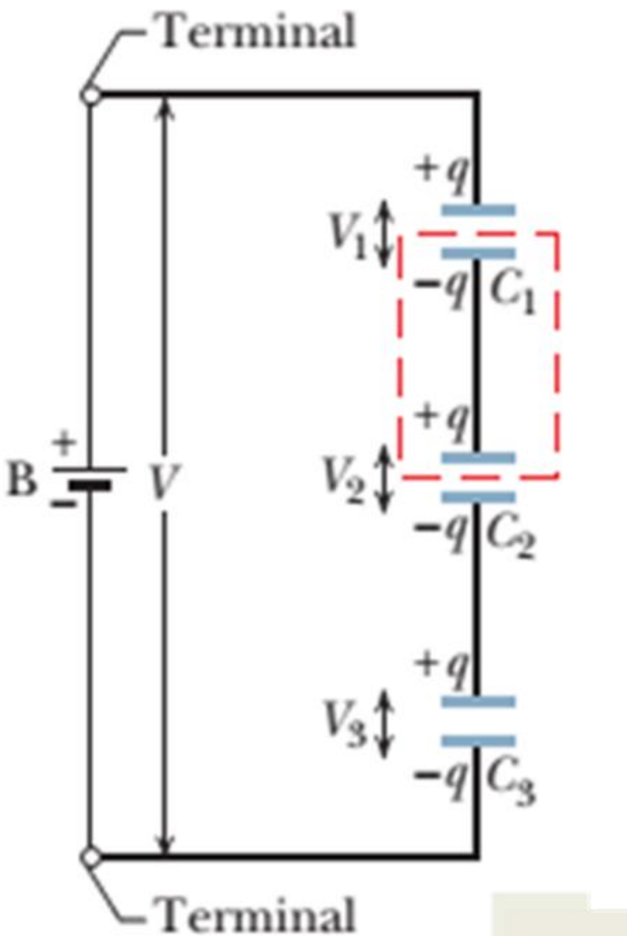
The total potential difference *V* due to the battery is the sum of these three potential differences. Thus,

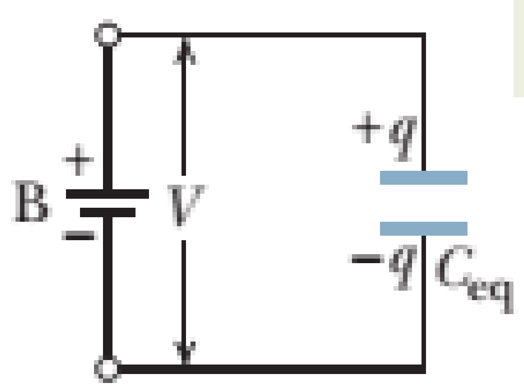
$$V = V_1 + V_2 + V_3 = q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

The equivalent capacitance is then

$$C_{eq} = \frac{q}{V} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

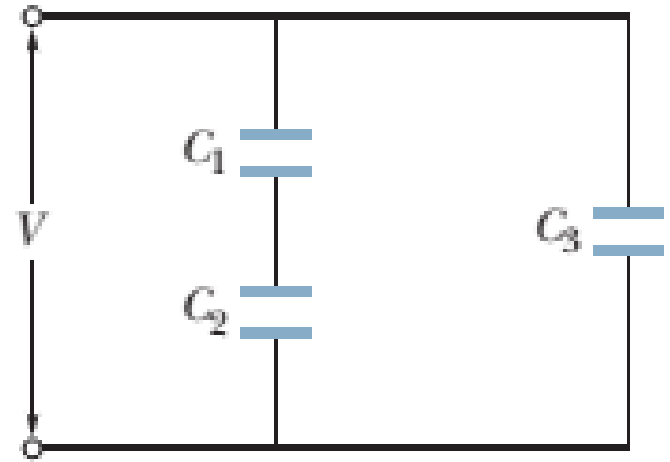
$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$





Problem 10 (Book chapter 25):

In the adjacent Figure, find the equivalent capacitance of the combination. Assume that C_1 is $10.00\ \mu F$, C_2 is $5.00\ \mu F$, and C_3 is $4.00\ \mu F$.



Given

$C_1 = 10\ \mu F \quad C_2 = 5\ \mu F$

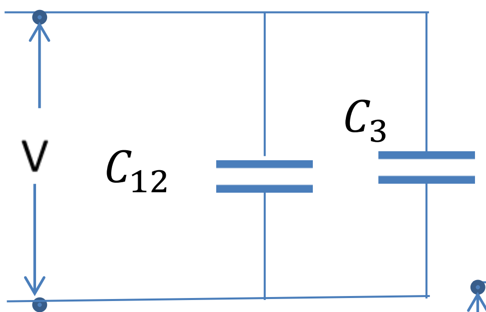
$C_3 = 4\ \mu F$

Answer:

Step1: $C_1\ and\ C_2\ are\ in\ series$

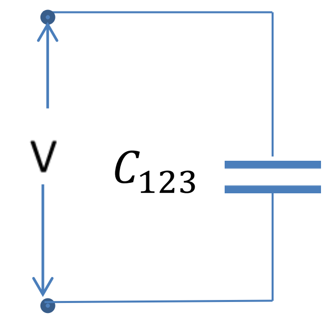
$$\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{or} \quad C_{12} = \frac{C_1 C_2}{C_2 + C_1}$$

$$C_{12} = \frac{(10)(5)}{5+10} = \frac{50}{15} = 3.33\ \mu F$$



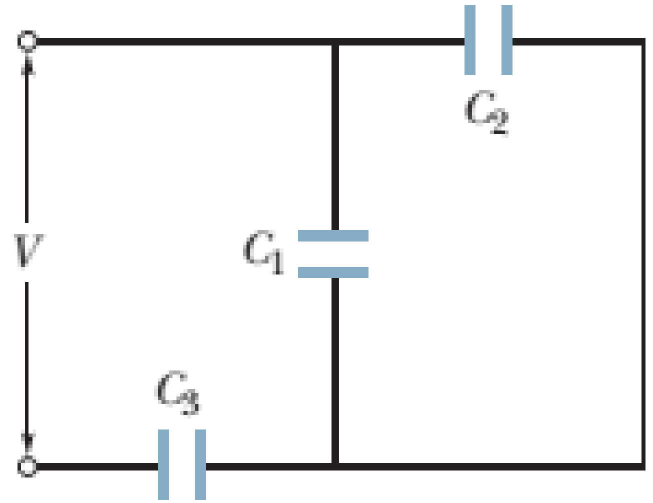
Step2: $C_{12}\ and\ C_3\ are\ in\ parellel$

$$C_{123} = C_{12} + C_3 = 3.33 + 4 = 7.33\ \mu F$$



Problem 11 (Book chapter 25):

In the adjacent Figure, find the equivalent capacitance of the combination. Assume that C_1 is $10.00\ \mu F$, C_2 is $5.00\ \mu F$, and C_3 is $4.00\ \mu F$.



Answer:

Step1: $C_1\ and\ C_2\ are\ in\ parellel$

$$C_{12} = C_1 + C_2 = 10 + 5 = 15\ \mu F$$

Given

$C_1 = 10\ \mu F$

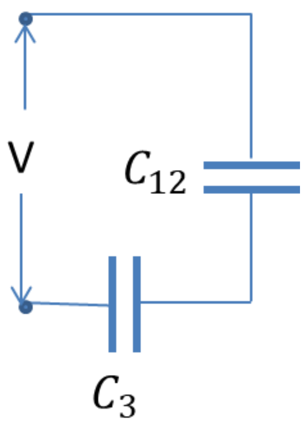
$C_2 = 5\ \mu F$

$C_3 = 4\ \mu F$

$C_{123} = ?$

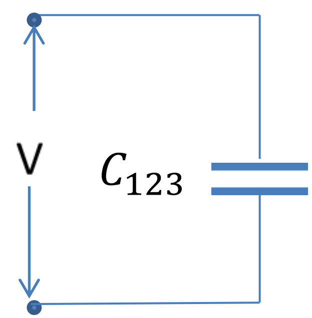
Step2: $C_{12}\ and\ C_3\ are\ in\ series$

$$\frac{1}{C_{123}} = \frac{1}{C_{12}} + \frac{1}{C_3} = \frac{C_3 + C_{12}}{(C_{12})(C_3)}$$



$$C_{123} = \frac{(C_{12})(C_3)}{C_3 + C_{12}}$$

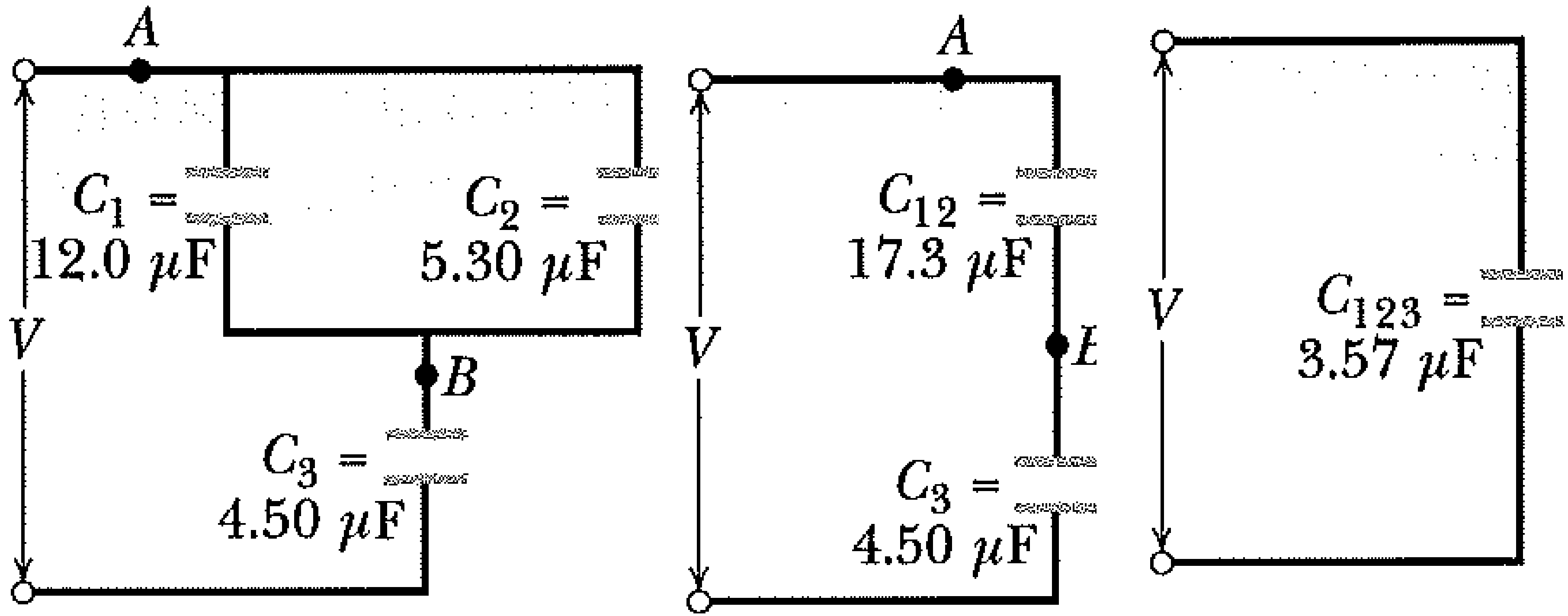
$$C_{123} = \frac{(15)(4)}{4+15} = \frac{60}{19} = 3.158\ \mu F$$



Sample Problem 25.02(a) (page 726): Find the equivalent capacitance for the combination of capacitances shown in Figure, across which potential difference V is applied.

Assume $C_1 = 12.0\ \mu F$, $C_2 = 5.30\ \mu F$, $and\ C_3 = 4.5\ \mu F$.

Home Task



Step1: $C_1\ and\ C_2\ are\ in\ parallel$

$$C_{12} = C_1 + C_2 = 12 + 5.3 = 17.3\ \mu F$$

Step2: $C_{12}\ and\ C_3\ are\ in$ series

$$\frac{1}{C_{123}} = \frac{1}{C_{12}} + \frac{1}{C_3} = \frac{C_3 + C_{12}}{(C_{12})(C_3)}$$

$$C_{123} = \frac{(C_{12})(C_3)}{C_3 + C_{12}}$$

$$C_{123} = \frac{(17.3)(4.5)}{4.5 + 17.3} = \frac{77.85}{21.8} = 3.57\ \mu F$$

Energy Stored in an Electric Field:

Suppose that, at a given instant, a charge q' has been transferred from one plate of a capacitor to the other. The potential difference V' between the plates at that instant will be $\frac{q'}{C}$. If an extra increment of charge dq' is then transferred, the increment of work required will be,

$$dW = V'dq' = \frac{q'}{C}dq'$$

The work required to bring the total capacitor charge up to a final value q is

$$W = \int_{q'=0}^{q'=q} dW = \frac{1}{C}\int_0^q q'dq' = \frac{q^2}{2C}$$

This work is stored as potential energy U in the capacitor, so

$$U = W = \frac{q^2}{2C} = \frac{(CV)^2}{2C} = \frac{1}{2}CV^2$$

Finally, $\boxed{U = \frac{q^2}{2C}}$ OR $\boxed{U = \frac{1}{2}CV^2}$

Thank You