Recitation 10

•1 The two metal objects in Fig. 25-24 have net charges of +70 pC and −70 pC, which result in a 20 V potential difference between them. (a) What is the capacitance of the system? (b) If the charges are changed to +200 pC and −200 pC, what does the capacitance become? (c) What does the potential difference become?

Fig. 25-24 Problem 1.

a)

$$C = \frac{q}{V} = \frac{70\ \text{pC}}{20\ \text{V}} = 3.5\ \text{pF}.$$

b) Same.

c)

$$V_2 = \frac{q_2}{C} = \frac{200\ \text{pC}}{3.5\ \text{pF}} = 57\ \text{V}.$$

••13 SSM ILW A 100 pF capacitor is charged to a potential difference of 50 V, and the charging battery is disconnected. The capacitor is then connected in parallel with a second (initially uncharged) capacitor. If the potential difference across the first capacitor drops to 35 V, what is the capacitance of this second capacitor?

$$q_1 + q_2 = q = C_1 V.$$

$$V_1 = V_2 = V'.$$

$$q_1 = C_1 V'.$$

$$q_2 = C_1 V - q_1 = C_1 V - C_1 V' = C_1 (V - V')$$

$$C_2 = \frac{q_2}{V'} = C_1 \frac{V - V'}{V'} = (100\ \mathrm{pF}) \frac{50\ \mathrm{V} - 35\ \mathrm{V}}{35\ \mathrm{V}} = 43\ \mathrm{pF}.$$

••21 SSM WWW In Fig. 25-36, the capacitances are $C_1 = 1.0\ \mu F$ and $C_2 = 3.0\ \mu F$, and both capacitors are charged to a potential difference of $V = 100$ V but with opposite polarity as shown. Switches S_1 and S_2 are now closed. (a) What is now the potential difference between points a and b? What now is the charge on capacitor (b) 1 and (c) 2?

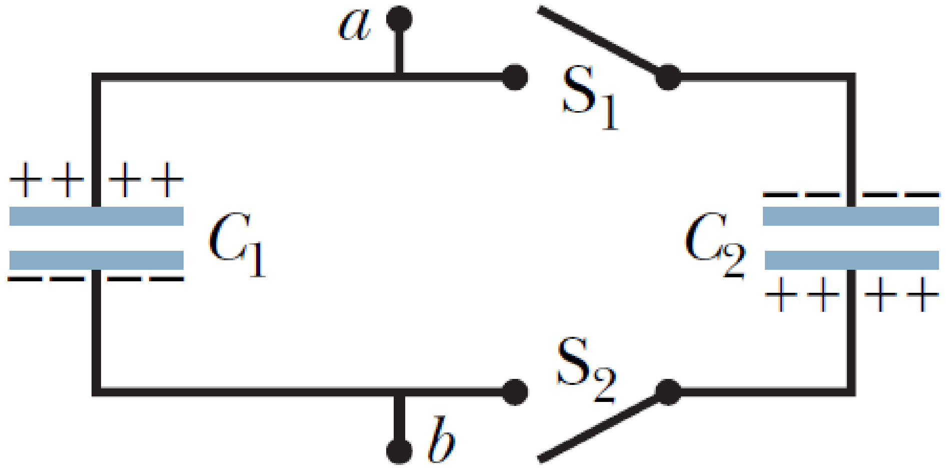


Fig. 25-36 Problem 21.

a)

$$q = q_2 - q_1 = (C_2 - C_1)V$$

$$V' = \frac{q}{C_{\text{eq}}} = \frac{C_2 - C_1}{C_2 + C_1}V = \frac{3.0\ \mu\text{F} - 1.0\ \mu\text{F}}{3.0\ \mu\text{F} + 1.0\ \mu\text{F}}(100\ \text{V}) = 50\ \text{V}.$$

b)

$$q_1 = C_1V' = (1.0\ \mu\text{F})(50\ \text{V}) = 50\ \mu\text{F}.$$

c)

$$q_2 = C_2V' = (3.0\ \mu\text{F})(50\ \text{V}) = 150\ \mu\text{F}.$$

••37 SSM ILW WWW The parallel plates in a capacitor, with a plate area of 8.50 cm^2 and an air-filled separation of 3.00 mm, are charged by a 6.00 V battery. They are then disconnected from the battery and pulled apart (without discharge) to a separation of 8.00 mm. Neglecting fringing, find (a) the potential difference between the plates, (b) the initial stored energy, (c) the final stored energy, and (d) the work required to separate the plates.

a)

$$V_2 = E\,d_2 = \frac{V_1}{d_1} d_2 = \frac{6.00\ \text{V}}{3.00\ \text{mm}}(8.00\ \text{mm}) = 16.0\ \text{V}.$$

b)

$$C_1 = \varepsilon_0 \frac{A}{d_1} = (8.85\ \text{pF})\frac{8.50 \times 10^{-4}\ \text{m}^2}{3.00 \times 10^{-3}\ \text{m}} = 2.51\ \text{pF}.$$

$$U_1 = \frac{1}{2} C_1 V_1^2 = \frac{1}{2}(2.51\ \text{pF})(6.00\ \text{V})^2 = 45.1\ \text{pJ}.$$

c)

$$U_2 = U_1 \frac{d_2}{d_1} = 45.1\ \text{pJ}\frac{8.00\ \text{mm}}{3.00\ \text{mm}} = 120\ \text{pJ}.$$

d)

$$W = U_2 - U_1 = 75.2\ \text{pJ}.$$

••54 Two parallel plates of area 100 cm^2 are given charges of equal magnitudes 8.9×10^{-7} C but opposite signs. The electric field within the dielectric material filling the space between the plates is 1.4×10^6 V/m. (a) Calculate the dielectric constant of the material. (b) Determine the magnitude of the charge induced on each dielectric surface.

a)

$$E_0 = \frac{V}{d} = \frac{q}{Cd} = \frac{q}{(\varepsilon_0 A/d)d} = \frac{q}{\varepsilon_0 A} = \frac{8.9 \times 10^{-7}\ \mathrm{C}}{(8.85\ \mathrm{pF})(100 \times 10^{-4}\ \mathrm{m}^2)}$$

$$= 1.0 \times 10^7 \,\frac{\mathrm{V}}{\mathrm{m}}.$$

$$\kappa = \frac{E_0}{E} = \frac{1.0 \times 10^7\ \mathrm{V/m}}{1.4 \times 10^6\ \mathrm{V/m}} = 7.2.$$

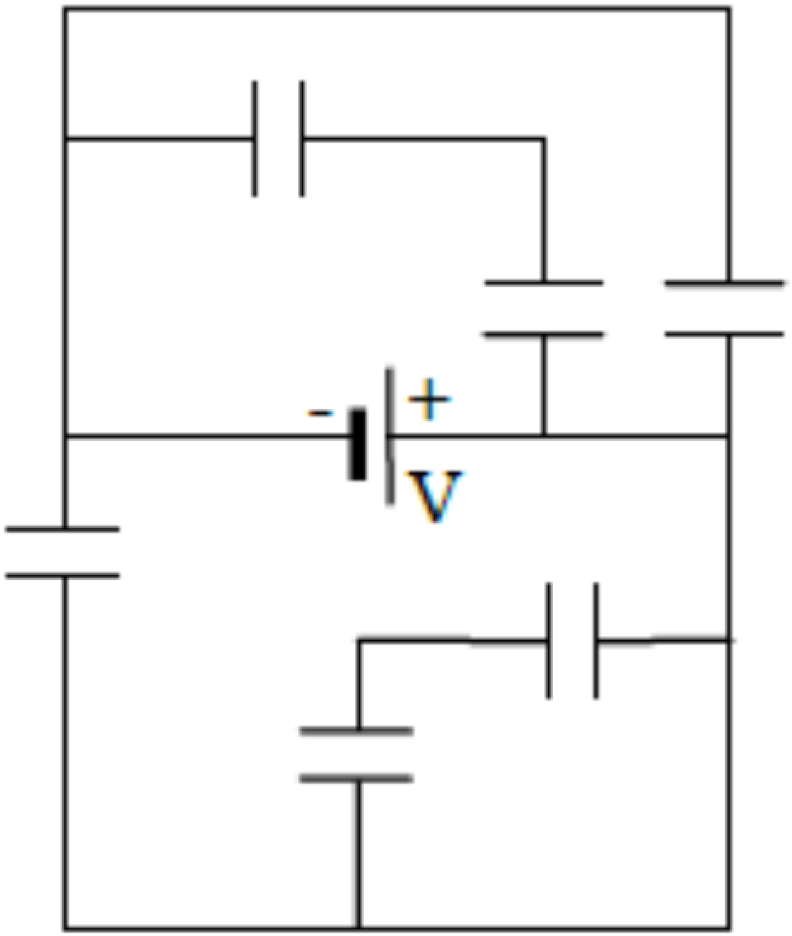
b)

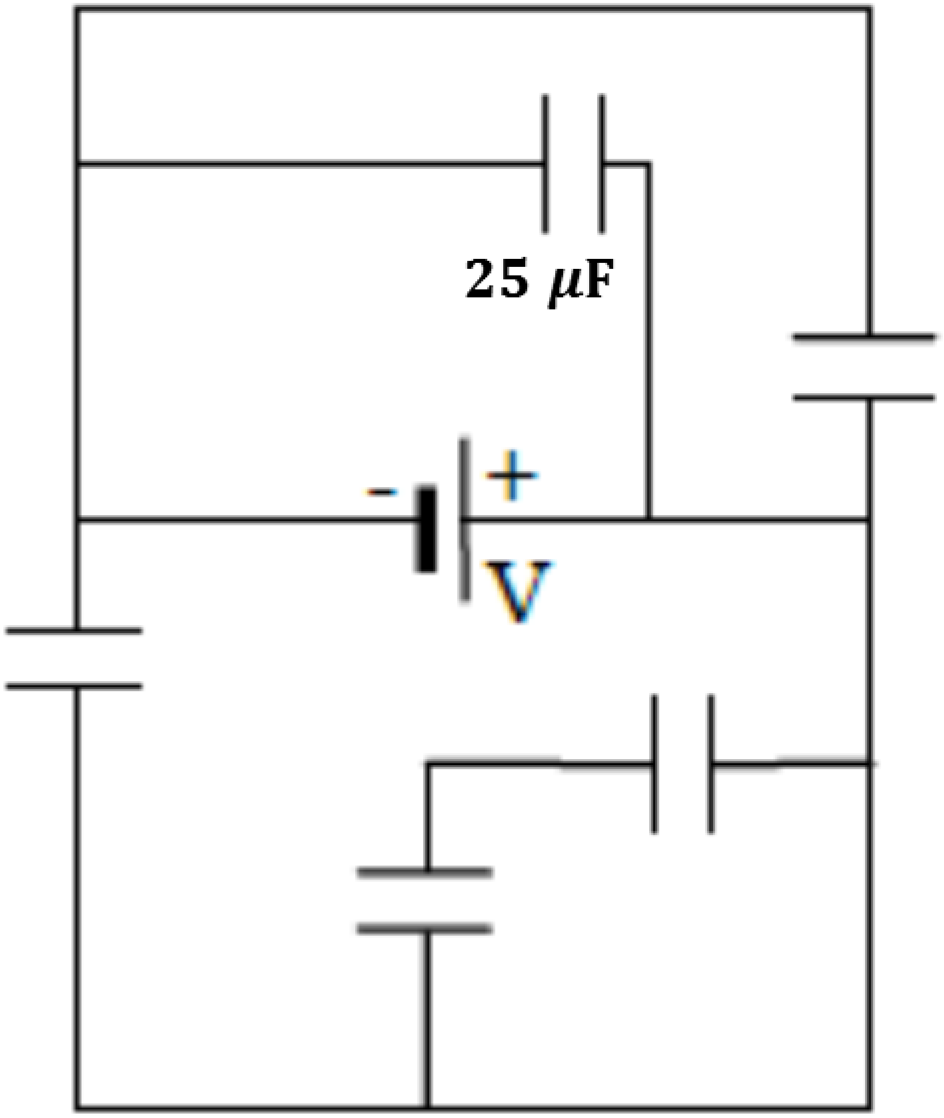
$$q - q' = \frac{q}{\kappa}$$

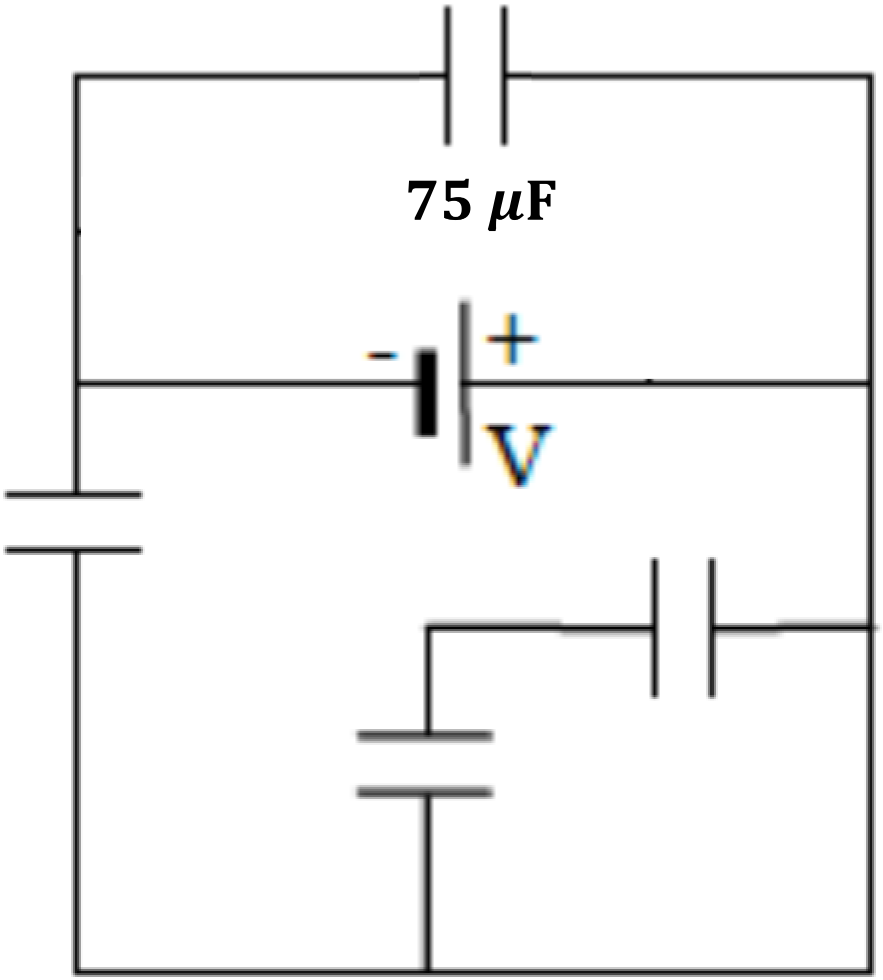
or

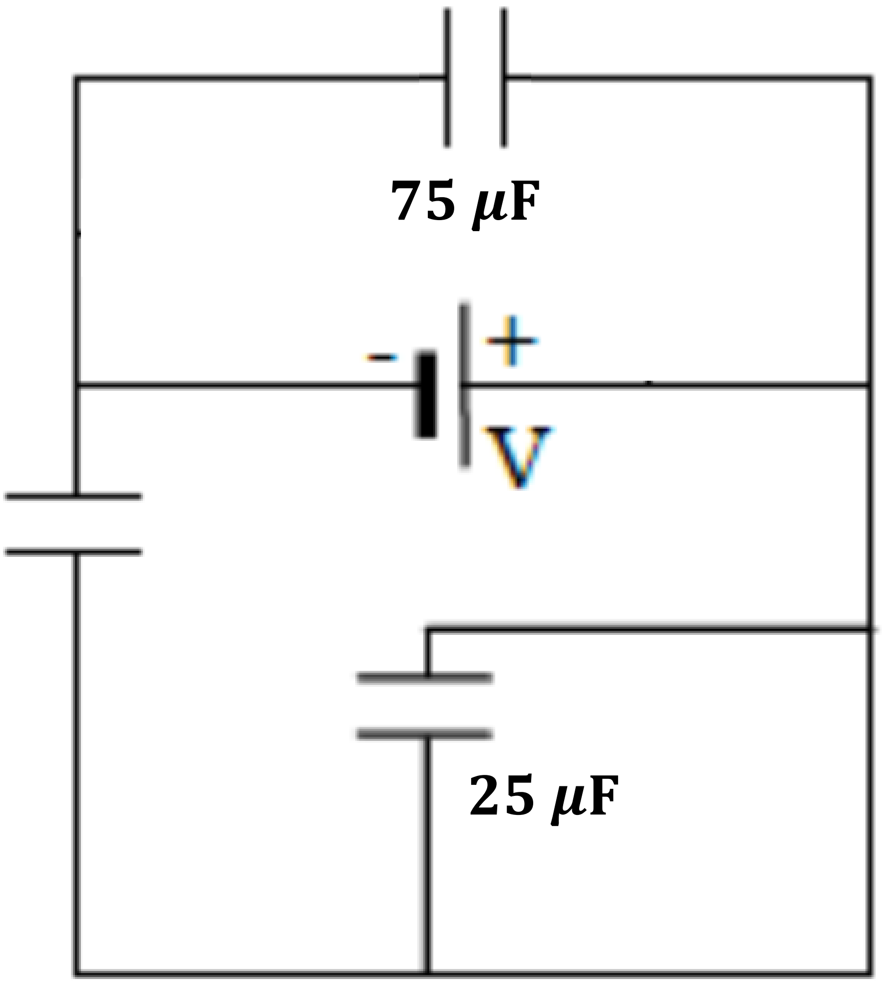
$$q' = (1 - 1/\kappa)q = (1 - 1/7.2)(8.9 \times 10^{-7}\ \mathrm{C}) = 7.7 \times 10^{-7}\ \mathrm{C}.$$

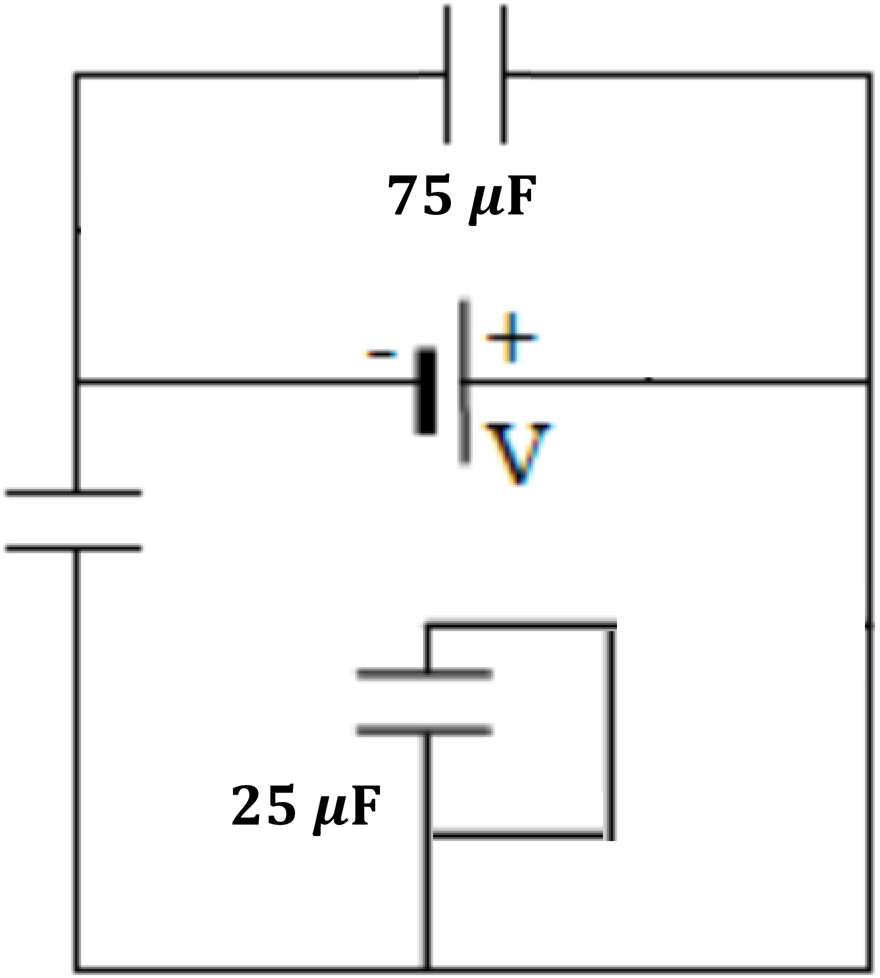
△◘**58.** Consider the circuit of identical capacitors shown in figure 28. A potential difference of 2.0×10^2 V is applied by the battery V. Calculate the energy stored in the system if the capacitance of each capacitor is 50 μF. (Ans: 2.5 J)

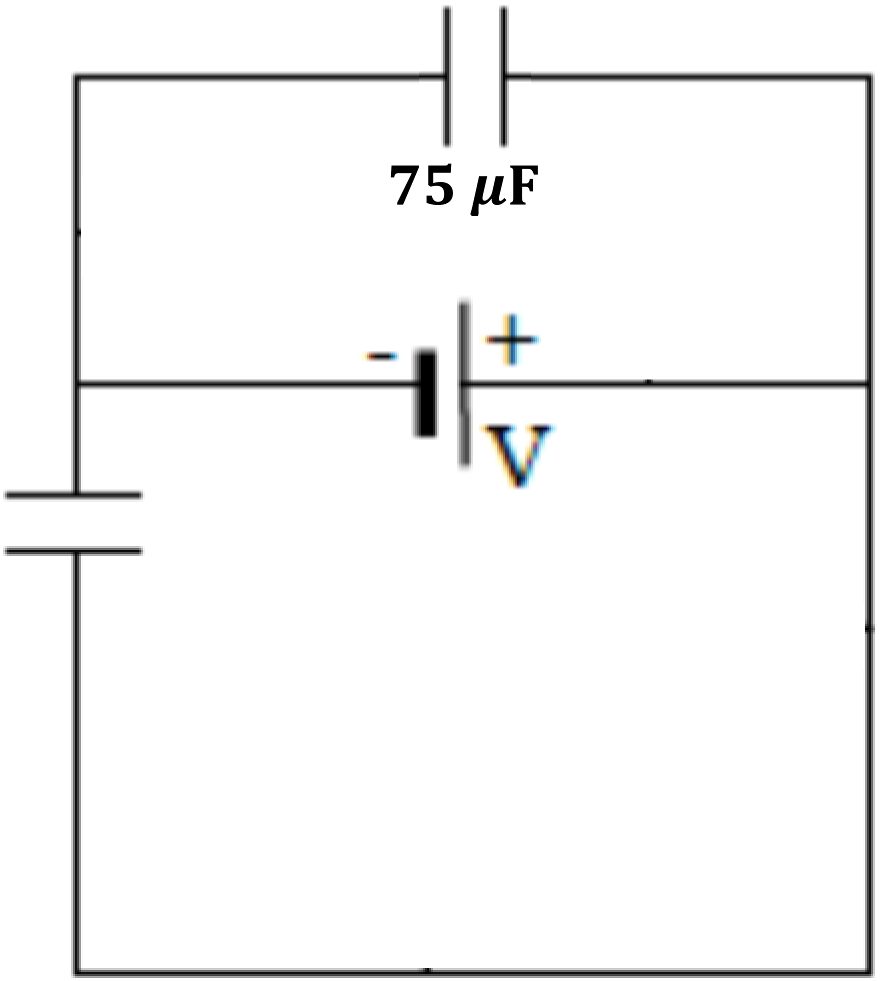


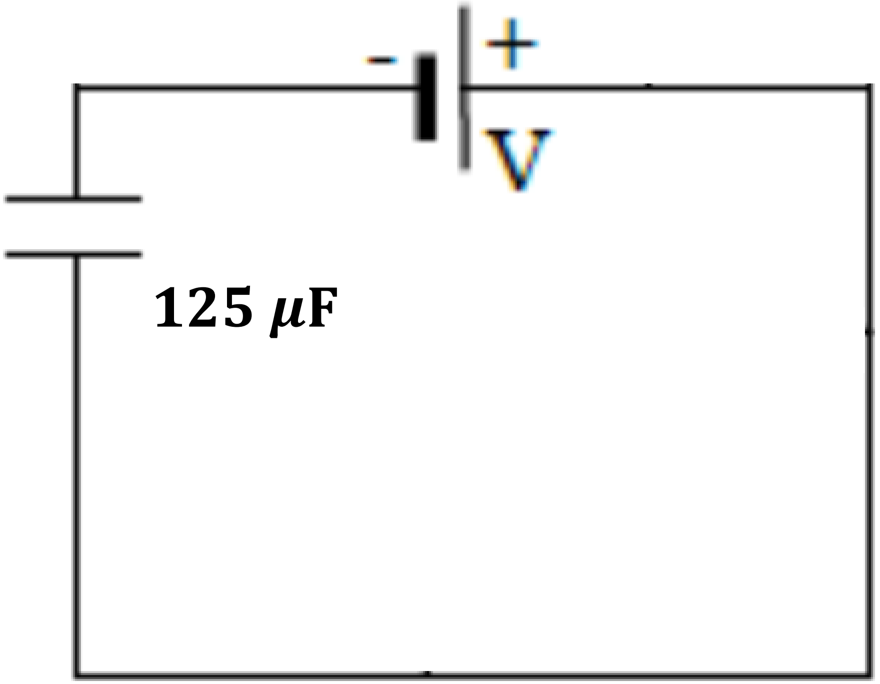

25 μF
-
+
V


75 μF
-
+
V


75 μF
- + V
25 μF


75 μF
-
+
V
25 μF


75 μF
-
+
V



$$U = \frac{1}{2}CV^2 = \frac{1}{2}(125\ \mu\text{F})(200)^2 = 2.5\ \text{J}$$