26장 전기용량과 유전체 연습문제 풀이

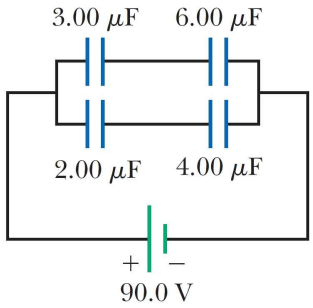
2. (a) 12.0 V전지에 연결되어 있는 4.00 μF 축전기의 판에는 얼마만큼의 전하량이 있는가?

(b) 같은 축전기가 1.50 V 전지에 연결되어 있다면 저장된 전하량은 얼마인가?

sol) (a) $Q = C\Delta V = (4.00\times10^{-6}\,\mathrm{F})(12.0\,\mathrm{V}) = 4.80\times10^{-5}\,\mathrm{C}$

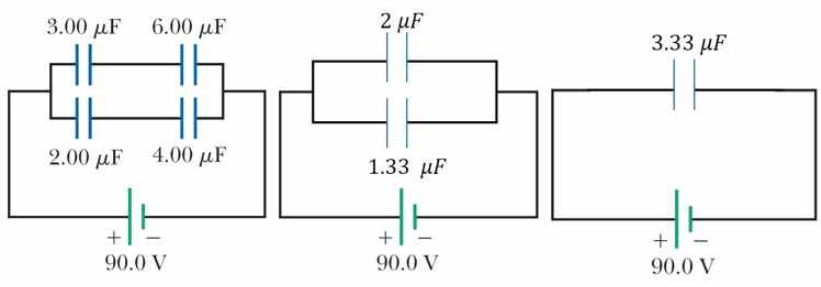
(b) $Q = C\Delta V = (4.00\times10^{-6}\,\mathrm{F})(1.50\,\mathrm{V}) = 6.00\times10^{-6}\,\mathrm{C}$

7. 그림의 회로는 90.0 V 전지와 네 개의 축전기로 구성되어 있다.



(a) 축전기 계의 등가 전기용량을 구하라.

sol)



직렬연결: $\dfrac{1}{C_{upper}} = \dfrac{1}{C_1}+\dfrac{1}{C_2} = \dfrac{1}{3.00\,\mu\mathrm{F}}+\dfrac{1}{6.00\,\mu\mathrm{F}} \rightarrow C_{\text{upper}} = 2.00\,\mu\mathrm{F}$

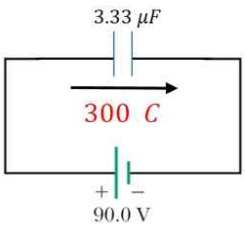
직렬연결: $\dfrac{1}{C_{lower}} = \dfrac{1}{C_1}+\dfrac{1}{C_2} = \dfrac{1}{2.00\,\mu\mathrm{F}}+\dfrac{1}{4.00\,\mu\mathrm{F}} \rightarrow C_{\text{lower}} = 1.33\,\mu\mathrm{F}$

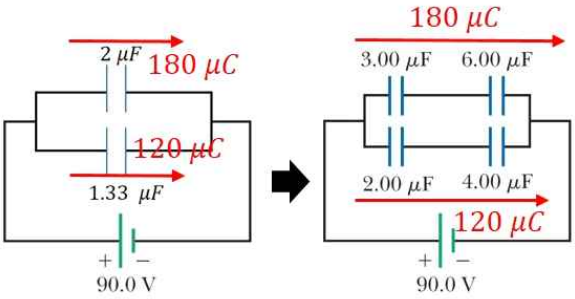
병렬연결: $C_{eq} = C_{upper} + C_{lower} = 2.00\,\mu\mathrm{F} + 1.33\,\mu\mathrm{F} = 3.33\,\mu\mathrm{F}$

(b) 각 축전기의 전하량을 구하라.

sol) 전체 전하량:

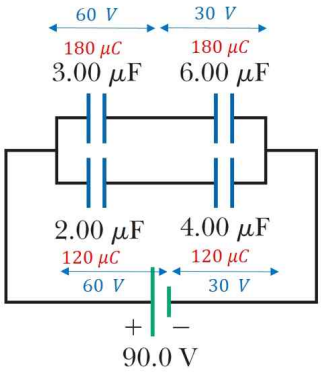
$Q = C\Delta V = (3.33\times10^{-6}\,\mathrm{F})(90.0\,\mathrm{V}) = 300\times10^{-6}\,\mathrm{C}$





$$Q_{3.00\,\mu F} = Q_{6.00\,\mu F} = Q_{upper} = C_{upper}\,(\triangle V) = (2.00\,\mu\text{F})(90.0\,\text{V}) = 180\,\mu\text{C}$$
$$Q_{2.00\,\mu F} = Q_{4.00\,\mu F} = Q_{upper} = C_{upper}\,(\triangle V) = (1.33\,\mu\text{F})(90.0\,\text{V}) = 120\,\mu\text{C}$$

(c) 각 축전기 양단의 전위차를 구하라.

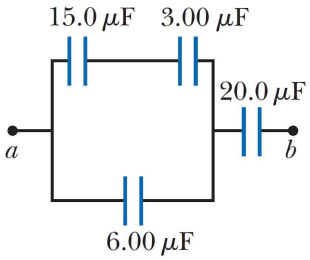


sol)

각 축전기 소자마다 $Q = C\triangle V \rightarrow \triangle V = \frac{Q}{C}$를 이용하여 계산 가능

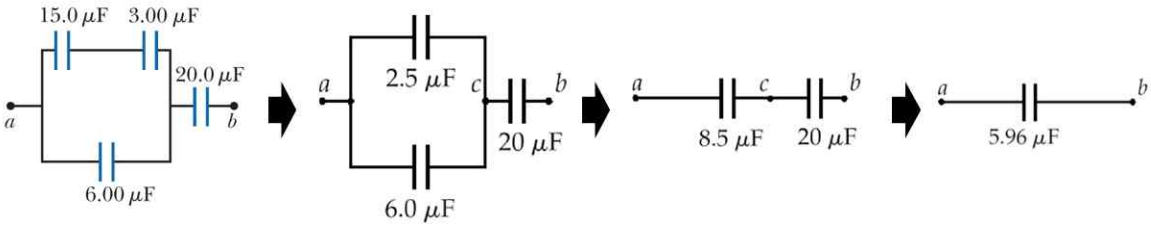
$$\triangle V_{3.00\,\mu\text{F}} = \frac{180\,\mu\text{C}}{3.00\,\mu\text{F}} = 60\,\text{V},\ \triangle\text{V}_{6.00\,\mu\text{F}} = \frac{180\,\mu\text{C}}{6.00\,\mu\text{F}} = 30\,\text{V}$$
$$\triangle V_{2.00\,\mu\text{F}} = \frac{120\,\mu\text{C}}{2.00\,\mu\text{F}} = 60\,\text{V},\ \triangle\text{V}_{4.00\,\mu\text{F}} = \frac{120\,\mu\text{C}}{4.00\,\mu\text{F}} = 30\,\text{V}$$

8. 그림과 같이 네 개의 축전기가 연결된 계가 있다.



(a) 점 a와 b사이의 등가용량을 계산하라.

sol)



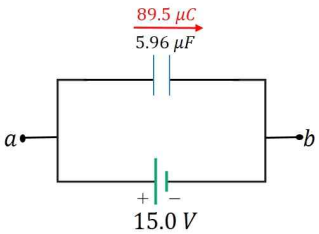
직렬연결 : $\frac{1}{C_{upper}} = \frac{1}{15\ \mu\text{F}} + \frac{1}{3.00\ \mu\text{F}} \rightarrow \text{C}_{\text{upper}} = 2.5\ \mu\text{F}$

병렬연결: $C = 2.5\ \mu\text{F} + 6.0\ \mu\text{F} = 8.5\ \mu\text{F}$

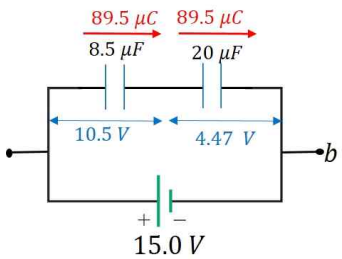
직렬연결 : $\frac{1}{C} = \frac{1}{8.5\ \mu\text{F}} + \frac{1}{20\ \mu\text{F}} \rightarrow \text{C} = 5.96\ \mu\text{F}$

(b) 점 a와 b 사이의 전위차 $\triangle V_{ab}$가 15.0 V일 때 각 축전기의 전하를 구하라.

sol)

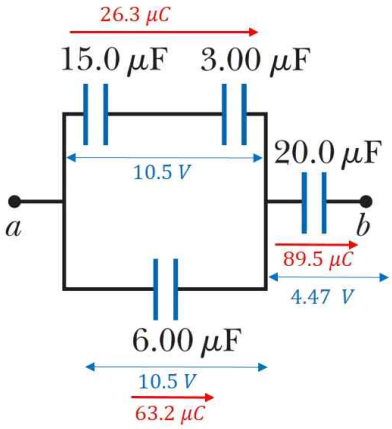


전체 전하량: $Q = C\triangle V = (5.96\ \mu\text{F})(15.0\ \text{V}) = 89.5\ \mu\text{C}$



$$\triangle V = \frac{\text{Q}}{C_{8.50\,\mu\text{F}}} = \frac{89.5\ \mu\text{F}}{8.50\,\mu\text{C}} = 10.5\ \text{V}$$

$$\triangle V = \frac{\text{Q}}{C_{20\,\mu\text{F}}} = \frac{89.5\ \mu\text{F}}{20.0\ \mu\text{C}} = 4.47\ \text{V}$$



축전기 $6.00\,\mu F$ 사이에 전위차 $\triangle V = 10.5\ V$ 일 때,
전하량 $Q = C\triangle V = (6.00\,\mu\text{F})(10.5\,\text{V}) = 63.2\,\mu\text{C}$ 이다.

두 축전기($C_{15.0\,\mu F}$와 $C_{3.00\,\mu F}$)와 다른 축전기($C_{6.00\,\mu F}$)이 병렬연결 이기 때문에, 두 축전기($C_{15.0\,\mu F}$와 $C_{3.00\,\mu F}$)에 있는 전하량은 $89.5\,\mu C - 63.2\,\mu C = 26.3\,\mu C$

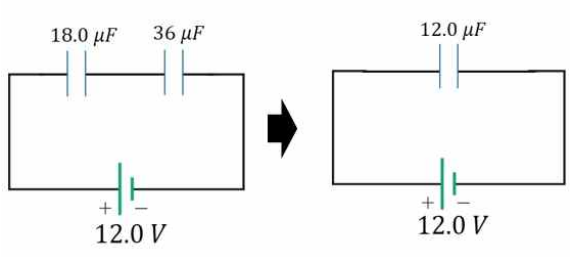
두 축전기($C_{15.0\,\mu F}$와 $C_{3.00\,\mu F}$)기는 직렬연결로 같은 전하량($26.3\,\mu\text{C}$) 을 가진다.

12. 어떤 축전기에 $12.0\,\text{V}$ 전지를 연결하여 충전시키니 전하가 $54.0\,\mu\text{C}$이다. 이 축전기에 저장된 에너지는 얼마인가?

sol) $U_E = \frac{1}{2}Q\triangle V = \frac{1}{2}(54.0\times10^{-6}\,\text{C})(12.0\,\text{V}) = 3.24\times10^{-4}\,\text{J}$

13. 전기용량이 $C_1 = 18.0\,\mu\text{F}$와 $C_2 = 36.0\,\mu\text{F}$ 인 두 개의 축전기가 있다. 이 둘을 직렬 연결하여 12.0 V 전지로 충전 시킨다.

(a) 두 축전기의 등가 전기용량을 계산하라.



sol)

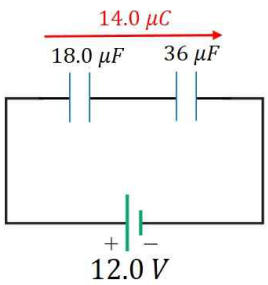
$$\frac{1}{C_{eq}} = \frac{1}{18.0\,\mu\text{F}} + \frac{1}{36.0\,\mu\text{F}} = \frac{1}{12.0\,\mu\text{F}} \rightarrow C_{eq} = 12.0\,\mu\text{F}$$

(b) 등가용량에 저장된 에너지를 계산하라.

sol) $U_E = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}(12\times10^{-6}\text{F})(12.0\text{ V})^2 = 8.64\times10^{-4}\text{ J}$

(c) 각각의 축전기에 저장된 에너지를 계산하라.

sol)



전체 전하량 $Q = C\Delta V = (12\times10^{-6}F)(12.0\ V) = 14.0\times10^{-6}C$

$$U_E = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{(14.0\times10^{-6}\text{C})^2}{(18.0\times10^{-6}\text{F}} = 5.76\times10^{-4}\text{ J}$$

$$U_E = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{(14.0\times10^{-6}\text{C})^2}{(36.0\times10^{-6}\text{F}} = 2.88\times10^{-4}\text{ J}$$

(d) 두 에너지를 더하면 (b)에서 구한 값과 같음을 보여라.

sol) (b)에서 계산된 에너지와 (c)에서 구한 각 축전기에 저장된 에너지의 합과 같다.

$$U_E = 8.64\times10^{-4}\text{ J} = 5.76\times10^{-4}\text{ J} + 2.88\times10^{-4}\text{ J}$$