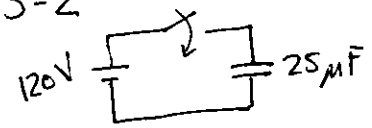
25-2



$Q = CV$
$= (25\mu F)(120V)$
$= 3\times10^{-3}$ Coul

25-4

a)

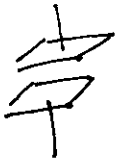
spherical capacitor
$a = 38mm$
$b = 40mm$

in middle $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$

$$\Delta V = -\int_b^a E\cdot dr = -\int_b^a \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}dr$$
$$= \frac{1}{4\pi\epsilon_0}\frac{Q}{r}\Big|_b^a$$
$$\Delta V = \frac{1}{4\pi\epsilon_0}Q\left(\frac{1}{a}-\frac{1}{b}\right)$$
$$4\pi\epsilon_0\left[\frac{1}{\frac{1}{a}-\frac{1}{b}}\right]\Delta V = Q$$

so comparing to $Q = C\Delta V$
identify
$$C = 4\pi\epsilon_0\left[\frac{1}{1/a - 1/b}\right]$$
$$= 4\pi(8.85-12)\left[\frac{1}{38\times10^{-3}} - \frac{1}{40\times10^{-3}}\right]$$
$$= 1.46\times10^{-10} \text{ Farad}$$

25-4 b)

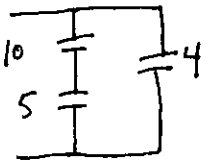


parallel plate
$$C = \frac{\epsilon_0 A}{d}$$

$C = 1.46\times10^{-10}$ Farad
$d = 2mm$

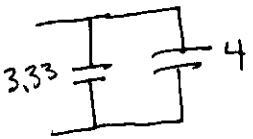
$$1.46\times10^{-10} = \frac{(8.85-12)A}{(2\times10^{-3})}$$
$$A = 3.31\times10^{-2} m^2$$
$$= 331 cm^2$$

25-10

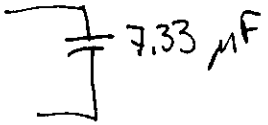


Values in μF

$$\frac{1}{C_{eff}} = \frac{1}{10} + \frac{1}{5} = \frac{3}{10}$$
$$C_{eff} = 10/3 = 3.33$$

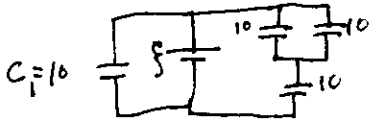


$$C_{eff} = 3.33 + 4$$
$$= 7.33$$



25-14

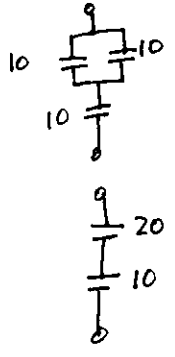
$\xi = 10$ Volts



a) we can actually answer part a) without doing any work when realize it has 10 volts across it

$$Q = C_1 V = (10\mu F)(10V)$$
$$= 100\ \mu Coul$$

b) For part b), we can actually just work with the right half of the circuit. there's 10 Volts.



Same Voltage

$\frac{10}{V = 3.33}$ $\quad$ $\frac{10}{V = 3.33}$

$Q = CV$ $\quad$ $Q = CV$

$= 10(3.33)$ $\quad$ $Q = 10(3.33)$

$= 33.3\ \mu Coul$ $\quad$ $= 33.3\ \mu Coul$

Same charge

$\frac{20}{Q = 66.6}$ $\quad$ $\frac{10}{Q = 66.6}$

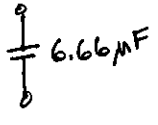
$Q = CV$ $\quad$ $Q = CV$

$66.6 = 20V$ $\quad$ $66.6 = 10V$

$V = 3.33$ $\quad$ $V = 6.66$

$$\frac{1}{C_{eff}} = \frac{1}{20} + \frac{1}{10}$$
$$= \frac{3}{20}$$
$$C_{eff} = 20/3 = 6.66\mu F$$

10 Volts



$\frac{6.66\mu F}{V = 10}$

$Q = CV$

$= (6.66\mu F)(10V)$

$= 66.6\ \mu Coul$

25-22

a) switch thrown to ~~left~~ puts charge on C_1

$$Q = C_1 V$$
$$Q = (10\mu F)(10V) = 100\mu Coul$$

call this $Q_{TOT} = 100\mu Coul$

b) when switch ~~thrown~~ to right this Q_{TOT} redistributes itself over $C_1\ C_2\ C_3$

So that $Q_{TOT} = Q_1 + Q_2 + Q_3$

Since the 3 caps are then in parallel, they will have the same voltage on each.

$$V_1 = V_2 = V_3 \xrightarrow{\text{call it}} V_f$$

Now write

$$Q_{TOT} = Q_1 + Q_2 + Q_3$$
$$= C_1V_1 + C_2V_2 + C_3V_3$$
$$= (C_1 + C_2 + C_3)\ V_f$$
$$100 = (10 + 20 + 20)\ V_f$$
$$2 = V_f$$

and then we can find the final charge on capacitor 1

$$Q_1 = C_1 V_f$$
$$= (10\mu F)(2)$$
$$= 20\mu Coul$$

25-31

$$U_{TOT} = \frac{1}{2}CV^2$$
$$= \frac{1}{2}(6\times10^{-6})(300)^2$$
$$= 0.27 \text{ Joules}$$

or if we were supposed to calculate the energy stored in each, ...

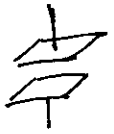
$\underline{2\mu F}$

$$U = \frac{1}{2}CV^2$$
$$= \frac{1}{2}(2-6)(300)^2$$
$$= 0.09 \text{ Joules}$$

$\underline{4\mu F}$

$$U = \frac{1}{2}CV^2$$
$$= \frac{1}{2}(4-6)(300)^2$$
$$= 0.18 \text{ Joules}$$

25-37



$$C = \frac{\epsilon_0 A}{d}$$

air dielectric

$A = 8.5 \text{ cm}^2 = 8.5\times10^{-4} \text{ m}^2$

$d = 3 \text{ mm} = 3\times10^{-3} \text{ m}$

Connected to 6 Volt battery

Initially $C = \frac{\epsilon_0 A}{d} = \frac{(8.85\times10^{-12})\,8.5\times10^{-4}}{3\times10^{-3}}$

$= 2.51\times10^{-12}$ Farad

initial $Q = CV$

$= (2.51\times10^{-12})(6) = 1.50\times10^{-11}$ Coul

initial $U = \frac{1}{2}CV^2 =$

$= \frac{1}{2}(2.51\times10^{-12})(6)^2 = 4.52\times10^{-11}$ Joules

Disconnected from battery.

Now when the plates are pulled apart, the charge has nowhere to go.

So afterward

$Q = 1.50\times10^{-11}$ Coul

new $C = \frac{\epsilon_0 A}{d} = \frac{(8.85-12)(8.5-4)}{(8-3)} = 9.40\times10^{-13}$

new $U = \frac{1}{2}C_{new}V_{new}^2$

$= \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{(1.50\times10^{-11})^2}{9.4\times10^{-13}}$

$= 1.20\times10^{-10}$ Joules.

new $Q_{new} = C_{new}V_{new}$

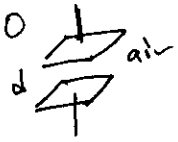
$1.50\times10^{-11} = 9.40\times10^{-13}\, V_{new}$

$V_{new} = 16.0$ Volts

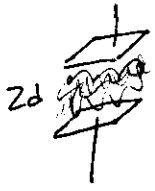
the change in energy is

$(1.20\times10^{-10}) - (4.52\times10^{-11}) = 7.48\times10^{-11}$ Joules

25-40



$$C_{init} = \frac{\epsilon_0 A}{d} = 1.3\,pF$$



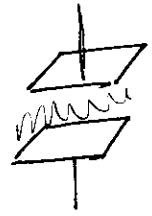
$$C_{final} = \frac{K\epsilon_0 A}{2d} = 2.6\,pF$$

$$C_{final} = \frac{K\,\epsilon_0 A}{2d} = 2.6\,pF$$

$$= \frac{K}{2}\,1.3 = 2.6$$

$$\rightarrow K = 4$$

25-45



$K = 5.5$

$A = 0.034\,m^2$

$d = 2\times10^{-3}\,m$

max electric field $E_{max} = 200\times10^{3}\ N/C$

$$C = \frac{K\epsilon_0 A}{d} = \frac{(5.5)(8.85\text{-}12)(0.034)}{2\times10^{-3}}$$

$$= 8.27\times10^{-10}\ \text{Farad}$$

since

$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$

$$|\Delta V| = Ed = (200\times10^{3})(2\times10^{-3})$$

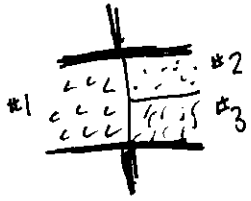
$$= 400\ \text{Volts}$$

Then

$$U = \frac{1}{2}CV^2 = \frac{1}{2}(8.27\times10^{-10})(400)^2$$

$$= 6.62\times10^{-5}\ \text{Joules}$$

25-50



$2d = 7.12\ mm$

$K_1 = 21$

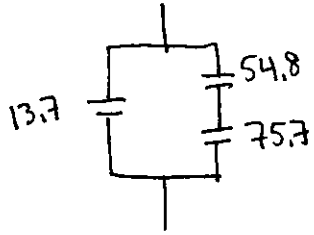
$K_2 = 42$

$K_3 = 58$

$A_{TOT} = 10.5\ cm^2 = 10.5 \times 10^{-4}\ m^2$

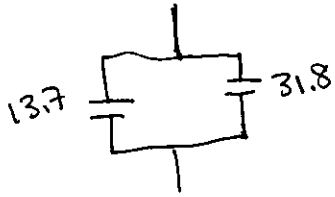
treat this as 3 capacitors

	C_1	C_2	C_3
dielectric	21	42	58
effective area	5.25×10^{-4}	5.25×10^{-4}	5.25×10^{-4}
separation	7.12×10^{-3}	3.56×10^{-3}	3.56×10^{-3}
$C = \frac{K\epsilon_0 A}{d}$	1.37×10^{-11}	5.48×10^{-11}	7.57×10^{-11}
	13.7 pF	54.8 pF	75.7 pF



$$\frac{1}{C_{eff}} = \frac{1}{54.8} + \frac{1}{75.7}$$

$$C_{eff} = 31.8\ pF$$



$$C_{eff} = 13.7 + 31.8$$
$$= 45.5\ pF$$