DP Physics

Solutions

Capacitor Structure Practice Problems

1 $C = \frac{q}{V} \Rightarrow V = \frac{q}{C} = \frac{7.2\times10^{-5}}{6.0\times10^{-6}} = \boxed{12\ V}$

2 $C_1 = \varepsilon_1 \frac{A_1}{d_1}$

a) If $A_2 = 2A_1$ $C_2 = \frac{\varepsilon_1 (2A_1)}{d_1} = \boxed{2C_1}$

b) If $d_3 = 2d_1$ $C_3 = \frac{\varepsilon_1 A_1}{2d_1} = \boxed{\frac{C_1}{2}}$

c) If $\varepsilon_2 = 2\varepsilon_1$ $C_4 = \frac{(2\varepsilon_1) A_1}{d_1} = \boxed{2C_1}$

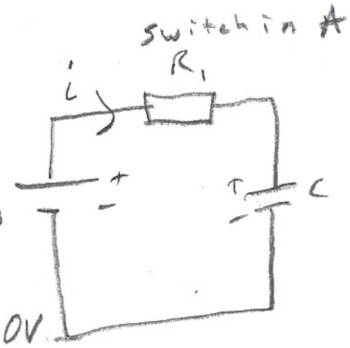
3 $C = \varepsilon \frac{A}{d} \Rightarrow C = \frac{K\varepsilon_0 A}{d} \Rightarrow K = \frac{C d}{\varepsilon_0 A} = \frac{(7.0\times10^{-6})(1\times10^{-5})}{(8.85\times10^{-12})(1.5)}$

$\boxed{K = 5.27}$

4 $C = \frac{q}{V} \Rightarrow q = CV = (2.5\times10^{-8})(45) = 1.125\times10^{-6}\ C$

$(1.125\times10^{-6}\ C)\left(\frac{1e^-}{1.6\times10^{-19}\ C}\right) = \boxed{7.03\times10^{12}\ e^-}$

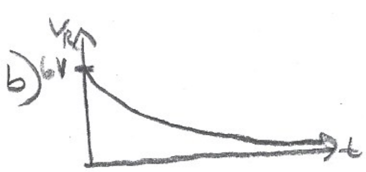
5 If switch is in position A $V_B - V_R - V_C = 0$



a) @ $t=0$ $V_c = 0 \Rightarrow 6 - iR_1 - 0 = 0$

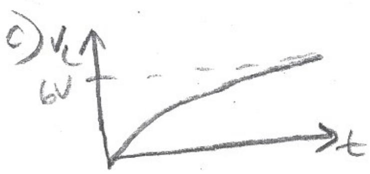
$6 - i(1000) = 0 \Rightarrow \boxed{i = 6\times10^{-3}\ A}$

b)



starts @ 6V and decreases to 0V

c)



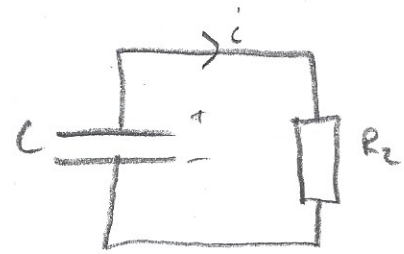
starts @ 0V and increases + 6V

$\tau_1 = R_1 C = (1000)(5\times10^{-6}) = 5\times10^{-3}\ s$

d) $E = \frac{1}{2}CV^2 = \frac{1}{2}(5\times10^{-6})(6)^2 = \boxed{9\times10^{-5}\ J}$

5 cont. e) $V_c - V_R = 0$

Switch in B



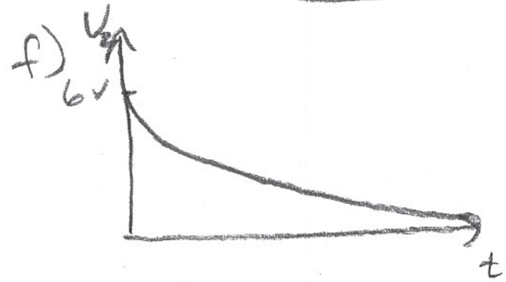
@ $t=0$ $V_c = 6V$

$6 - iR_2 = 0$

$6 - i(100) = 0$

$\boxed{i = 6\times10^{-2}\,A}$

f)



Starts @ 6V and decays to 0V.

g) Energy is converted to heat by the resistor.

h) $\tau_B = R_2 C = (100)(5\times10^{-6}) = 5\times10^{-4}\,s$

Compare time to $\frac{V}{2}$ or 3V using $V = V_0 e^{-\frac{t}{\tau}}$

Switch in A
$\tau_A = 5\times10^{-3}\,s$　　$3 = 6e^{-\frac{t}{(5\times10^{-3})}} \Rightarrow 0.5 = e^{-\frac{t}{(5\times10^{-3})}} \Rightarrow -\ln(0.5) = \frac{t_A}{5\times10^{-3}}$

$t_A = 0.0035\,s$

Switch in B
$\tau_B = 5\times10^{-4}\,s$　　$3 = 6e^{-\frac{t_B}{(5\times10^{-4})}} \Rightarrow 0.5 = e^{-\frac{t_B}{5\times10^{-4}}} \Rightarrow -\ln(0.5) = \frac{t_B}{5\times10^{-4}}$

$t_B = 0.00035\,s$

The time to half charge $t_{\frac{1}{2}A} = 10\,t_{\frac{1}{2}B}$. It would take 10x as long to charge as to discharge.

(For an application, look up the flash on a camera)