① 3.5: Corrente elétrica e DC

1) $A = 7{,}0\,cm^2$

$Ag^+NO_3^-$

$V = 12V$

$R = 1{,}8\Omega$

$l = 0{,}133\,mm$

$\rho = 10{,}5\times10^3\,kg/m^3$

$m. = 107{,}87\,g/mole$

$$V = A\times h = 7\times10^{-4}\times 0{,}133\times10^{-3} = 9{,}31\times10^{-8}\,m^3$$

$$m_{Ag} = \rho V = 10{,}5\times10^3\times 9{,}31\times10^{-8} = 9{,}78\times10^{-4}\,kg$$

nº de átomos da prata:

$$N = 9{,}78\times10^{-4}\times\frac{6{,}02\times10^{23}}{107{,}87\times10^{-3}} = 5{,}46\times10^{21}\text{ átomos}$$

$$I = \frac{V}{R} \Leftrightarrow I = \frac{12}{1{,}8} = 6{,}67\,A\ (C/s)$$

$$\Delta t = \frac{\Delta Q}{I} = \frac{Ne}{I} = \frac{5{,}46\times10^{21}\times1{,}60\times10^{-19}}{6{,}67} = 131\,s$$

2) $I(t) = I_0\,e^{-t/\tau}$ $\boxed{dq = I\,dt}$

a) $t=0$ e $t=\tau$

$\Delta t = \tau - 0 = \tau$

$$Q(t) = \int_0^t I_0 e^{-t/\tau}\,dt = I_0\left[-\tau e^{-\frac{t}{\tau}}\right]_0^t$$

$$= I_0(-\tau)\left[e^{-t/\tau} - 1\right]$$

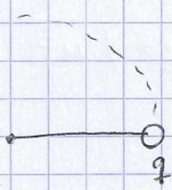
$$= +I_0\tau\left(1 - e^{-\frac{t}{\tau}}\right)$$

logo, $t=\tau \Rightarrow Q(\tau) = I_0\tau(1-e^{-1})\ C$

b) $Q(10\tau) = I_0\tau(1-e^{-10})\ C$

c) $\lim_{t\to\infty} Q(t) = I_0\tau(1-e^{-\infty}) = I_0\tau$

3)



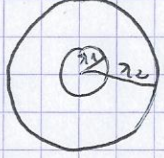
$\boxed{I = \frac{Q}{T}}$ $w = \frac{2\pi}{T} \Leftrightarrow T = \frac{2\pi}{w}\ (s)$

w

$I = ?$

logo $I = \frac{q}{\frac{2\pi}{w}} = \frac{qw}{2\pi}$

4)



$w = 2\pi T$

$I = \frac{Q}{T} = \frac{Q}{\frac{2\pi}{w}} = \frac{Q w}{2\pi}$

5) $l = 1{,}5\ m$

$A = 0{,}60\ mm^2$

$\Delta V = 0{,}90\ V$

$\rho = 5{,}6 \times 10^{8}\ \Omega m$

$I = \frac{\Delta V}{R} = \frac{0{,}90}{R}$

$R = \frac{L}{\sigma A} = \frac{1}{\sigma} \cdot \frac{L}{A} = \rho \frac{L}{A} = 5{,}6 \times 10^{-8} \times \frac{1{,}5}{0{,}60 \times 10^{-6}}$

$\Leftrightarrow R = 0{,}14\ \Omega$

logo $I = \frac{0{,}90}{0{,}14} = 6{,}43\ A$

6)

$m = 90{,}0\ g$

$\rho_v = 10{,}5\ g/cm^3$

a) $R = \rho \frac{l}{A} = \rho \frac{l}{l^2} = \frac{\rho}{l}$

Sabe-se que $\rho_v = \frac{m}{V} \Leftrightarrow$

$\Leftrightarrow l^3 = \frac{m}{\rho_v} \Leftrightarrow l = \sqrt[3]{\frac{90 \times 10^{-3}}{10{,}5 \times 10^{-3}}} \Leftrightarrow l = 2{,}05\ cm$

Tabela: $\rho = 1{,}59 \times 10^{-8}\ \Omega . m$

logo $R = \frac{1{,}59 \times 10^{-8}}{2{,}05 \times 10^{-2}} = 7{,}76 \times 10^{-7}\ \Omega$ (arredondado!)

b) $1e \rightarrow 1$ átomo

$V = 10{,}0\ mV$

$I = nqAv$

$n \rightarrow$ nº eletrões/m^3
$q \rightarrow$ carga elementar
$v \rightarrow$ velocidade média

$I = \frac{\Delta V}{R} = \frac{10 \times 10^{-3}}{7{,}76 \times 10^{-7}} = 1{,}29 \times 10^{4}\ A$

$1 cm^3 = (10^{-2})^3 = 10^{-6} m^3$

$n = \frac{\overset{g/cm^3}{10{,}5 \times 10^{6}}}{107{,}87} \times 6{,}02 \times 10^{23} = 5{,}86 \times 10^{28}$ eletrões/m^3

$v = \frac{I}{nqA} = \frac{1{,}28 \times 10^{4}}{5{,}86 \times 10^{28} \times 1{,}60 \times 10^{-19} \times (2{,}05 \times 10^{-2})^2}$

$= 3{,}25 \times 10^{-3}\ m/s$

② 7) R

$l' = 1,25\,l$

$R = \rho \frac{l}{A}$ $\qquad R' = \rho \frac{1,25\,l}{(A/1,25)} = 1,25^2 \rho \frac{l}{A} = 1,56\,R$

a) ↗

b) 

$R = \frac{\rho l}{\pi r^2} \Leftrightarrow r^2 = \frac{\rho l}{\pi R}$

$\Leftrightarrow r = \sqrt{\frac{\rho l}{\pi R}} \Leftrightarrow d = 2\sqrt{\frac{\rho l}{\pi R}}$

8) carvão $\rho_c = 3,5\times10^{-5}\ \Omega.m$

níquel $\rho_n = 1,50\times10^{-6}\ \Omega.m$

$R = 10\,k\Omega$ $\qquad R = \rho\frac{l}{A} = \rho(T)\frac{l}{A}$

Série $\qquad R = R_c + R_n$ $\qquad = \rho_0\left[1+\alpha(T-T_0)\right]\frac{l}{A}$

$R_c = R_c\left[1 - 0,5\times10^{-3}(T-T_0)\right]$

$R_n = R_n\left[1 + 0,4\times10^{-3}(T-T_0)\right]$

$\cancel{R_c} + \cancel{R_n} = \cancel{R_c} - 0,5\times10^{-3} R_c(T-T_0) + \cancel{R_n} + 0,4\times10^{-3} R_n(T-T_0)$

$0,5\times10^{-3} R_c \cancel{(T-T_0)} = 0,4\times10^{-3} R_n \cancel{(T-T_0)}$

$R_c = 0,8\,R_n$

logo,

$R = R_c + R_n = 1,8\,R_n$

e $R_n = \frac{10\times10^{+3}}{1,8} = 5,56\times10^{3}\ \Omega$

$\Rightarrow R_c = 10\times10^{3} - 5,56\times10^{3} = 4,44\times10^{3}\ \Omega$

9) $R = 1,00\ \Omega \rightarrow 20°C$ $\qquad R = R_0\left(1+\alpha(T-T_0)\right)$

$-196°C$ $\qquad R = 1\left(1 + 3,92\times10^{-3}(-196-20)\right)$

$\alpha = 3,92\times10^{-3}/°C$ $\qquad R = 0,15\ \Omega$ //

10) $P = 500\ W$

a) $T_0 = 20°C$

$I = \frac{\Delta V}{R}$

$\Delta V = 220V$

$P = I\Delta V = \frac{(\Delta V)^2}{R} \Leftrightarrow$

$d = 0,5\ mm$

$\Downarrow$

$r = 0,25$

$\Leftrightarrow R = \frac{220^2}{500} = 96,8\ \Omega$

$R = \frac{\rho l}{A} \Leftrightarrow l = \frac{AR}{\rho} = \frac{\pi \times (0,25 \times 10^{-3})^2 \times 96,8}{1,50 \times 10^{-6}} = 12,7\ m$

b) $T = 1200°C$

$R = R_0 \left[1 + \alpha (T - T_0)\right]$

$= 96,8 \left[1 + 0,4 \times 10^{-3} \times 1180\right] = 142,5\ \Omega$

logo, $P = \frac{220^2}{142,5} = 339,6\ W$

11) $l = 25\ m$

a) $\Delta V = E l \Leftrightarrow E = \frac{\Delta V}{l} = \frac{IR}{l} =$

$d = 0,4\ mm$

$= \frac{I \rho \frac{l}{A}}{l} = \frac{I\rho}{A} =$

$T_0 = 20°C$

$I = 0,5A$

$= \frac{0,5 \times 1,50 \times 10^{-6}}{\pi \times (0,2 \times 10^{-3})^2} = 5,97\ V/m$

b) $P = I . \Delta V = I . IR = I^2 . \rho . \frac{l}{A} = 0,5^2 \times 1,50 \times 10^{-6} \times \frac{25}{\pi (0,2 \times 10^{-3})^2} =$

$= 74,6\ W$

c) $T = 340°C$

$R = R_0 \left[1 + \alpha (T - T_0)\right]$

$R = 1,50 \times 10^{-6} \times \frac{25}{\pi (0,2 \times 10^{-3})^2} \left[1 + 0,4 \times 10^{-3} \times 320\right]$

$R = \underbrace{298,42}_{R_0} \times 1,128 = 336,62\ \Omega$

$P = \frac{(\Delta V)^2}{R}$ mas $\Delta V_0 = I_0 R_0 = 0,5 \times 298,42 = 149,21$

$= \frac{149,21^2}{336,62} = 66,14\ W$

(3)

12) niquel $\rho = 1{,}50\times10^{-6}\ \Omega.m$ $\alpha = 0{,}4\times10^{-3}$

$\Delta V = 120V$

$T_0 = 20°C$

$I_0 = 1{,}8A$ $- I_1 = 1{,}53A$

a) $\mathcal{P} = I\Delta V = 1{,}53\times120 = 183{,}6\ W$

b) $R = R_0\left(1+\alpha\left(T-T_0\right)\right)$

$R_0 = \dfrac{\Delta V}{I_0} = \dfrac{120}{1{,}8} = 66{,}7\ \Omega$

$R = \dfrac{\Delta V}{I} = \dfrac{120}{1{,}53} = 78{,}4\ \Omega$

logo, $\dfrac{120}{1{,}53} = \dfrac{120}{1{,}8}\left(1+\alpha\left(T-20\right)\right)$

$$T = \frac{\frac{1{,}8}{1{,}53}-1}{0{,}4\times10^{-3}} + 20$$

$T = 461°C$ //

13) $R = 5{,}6\ \Omega$

$r = R_{int} = 0{,}20\ \Omega$

$\Delta V = 10V$

$\Delta V = IR \Leftrightarrow I = \dfrac{\Delta V}{R}$

$\Leftrightarrow I = \dfrac{10}{5{,}6} = 1{,}79\ A$

$\Delta V = \varepsilon - Ir$

$10 = \varepsilon - 1{,}79\times0{,}20 \quad \Leftrightarrow \varepsilon = 10{,}4\ V$

14) $\varepsilon = 12{,}6\ V$

$r = 0{,}080\ \Omega$

$R = 5{,}0\ \Omega$

a) $I = \dfrac{\varepsilon}{r+R} = \dfrac{12{,}6}{0{,}080+5{,}0} = 2{,}48\ A$

$\Delta V = IR = 2{,}48\times5 = 12{,}4\ V$

b) $I = 35A$ $\quad I_{bateria} = I_{farois} + 35{,}0$

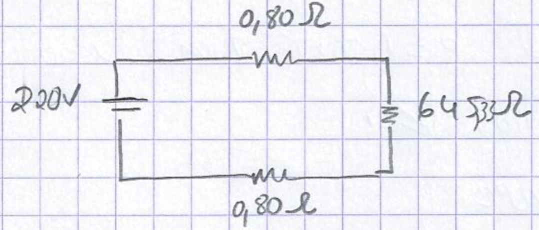
\# O motor arranca: $\boxed{I_b r + I_f R = \varepsilon}$

$12{,}6 = (I_f + 35)0{,}08 + I_f\times5 \Leftrightarrow 12{,}6 = 5{,}08 I_f + 2{,}8 \Leftrightarrow$

$\Leftrightarrow I_f = 1{,}93\ A$

logo $\Delta V = IR = 1{,}93\times5 = 9{,}65\ V$

(15) $P = 75 W$
$\Delta V = 220 V$



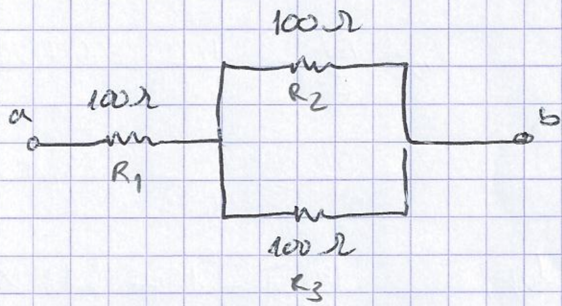
$R = 0{,}80 \Omega$
$IR = \Delta V$

$$P = I\Delta V \Leftrightarrow P = \frac{(\Delta V)^2}{R} \Leftrightarrow R = \frac{220^2}{75} = 645{,}33 \Omega$$

Na realidade, $R_{eq} = 0{,}80 + 0{,}80 + 645{,}33 = 646{,}93 \Omega$

$$P = \frac{(\Delta V)^2}{R} = \frac{220^2}{646{,}93} = 74{,}8 W$$

16) $P_{máx} = 25 W$



a) 1º determinar a $I_{máx}$

$$P = I_{máx}^2 \times R$$

$$25 = I^2 \times 100 \Leftrightarrow I = 0{,}5 A$$

Mas, $R_{eq_1} = \frac{100 \times 100}{100 + 100} = 50 \Omega$

$$R_{eq} = 100 + 50 = 150 \Omega$$

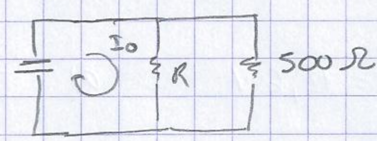
logo, $\Delta V_{máx} = R_{eq} I_{máx} = 150 \times 0{,}5 = 75 W$

b) $P_T = I\Delta V = 0{,}5 \times 75 = 37{,}5 W$ Potência total

$P_1 = 25 W$

$$P_2 = P_3 = \frac{37{,}5 - 25}{2} = 6{,}25 W$$

17) I_0
$I = 3I_0$ $R_1 = 500\Omega // R$

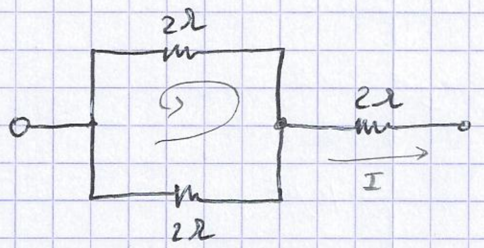


$$\left.\begin{aligned} \Delta V &= I_0 R \\ \Delta V &= I \left(\frac{R * 500}{R + 500}\right) \end{aligned}\right\} \Leftrightarrow \cancel{I_0} \cancel{R} = 3\cancel{I_0} \left(\frac{500 \cancel{R}}{500 + R}\right)$$

$$\Leftrightarrow 500 + R = 1500 \Leftrightarrow R = 1000 \Omega$$

4

18)



$P = 32W$

$R_{eq_{\perp}} = \frac{2\times 2}{2+2} = 1\ \Omega \Rightarrow R = 1 + 2 = 3\ \Omega$

de cada R:

$P = I^2 R \Leftrightarrow 32 = I^2 \times 2 \Leftrightarrow I = 4\ A$

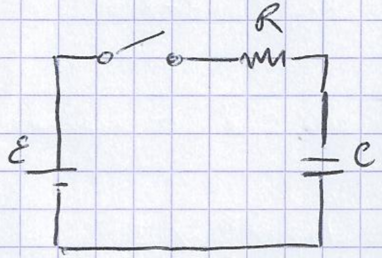
logo na combinação:

$P = I^2 R_{eq} \Leftrightarrow P = 4^2 \times 3 = 48W$

19) $R = 1\ M\Omega = 1\times10^6\ \Omega$

$C = 5\mu F = 5\times10^{-6} F$

$\mathcal{E} = 30V$



a) $\tau = RC = 1\times10^6 \times 5\times10^{-6} = 5\ s$

b) $Q = C\mathcal{E} = 5\times10^{-6} \times 30 = 150\times10^{-6}\ C$

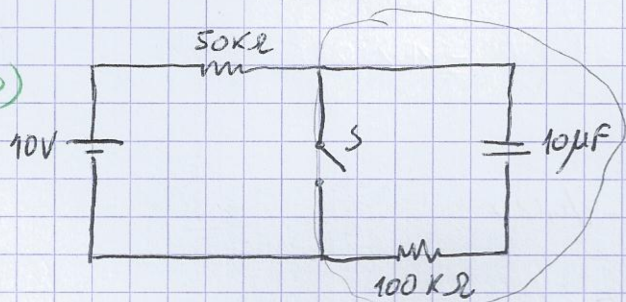
c) $t = 0\ s$ $\downarrow$ $t_f = 10\ s$

$I(t) = I_0\, e^{-t/\tau}$

$I_0 = \frac{\mathcal{E}}{R} = \frac{30}{1\times10^6} = 30\times10^{-6}\ A$

$I(10) = +30\times10^{-6}\, e^{-2} = +4,1\times10^{-6}\ A$

20)



a) $\tau = RC$

Antes: $R_{eq} = 100 + 50 = 150\ K\Omega$

$\tau = 150\times10^3 \times 10\times10^{-6} = 1,5\ s$

depois: $R = 100\ K\Omega$ $\quad \tau = 100\times10^3 \times 10\times10^{-6} = 1,0\ s$

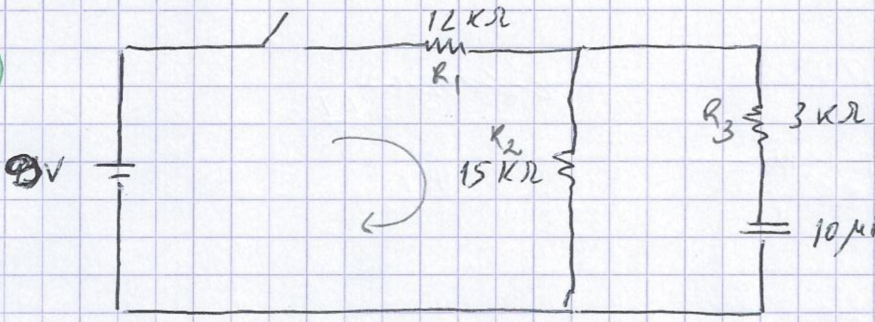
b) $I = I_{bateria} + I_{RC} \Leftrightarrow$

$I_0 = \frac{\mathcal{E}}{R} = \frac{10}{100\times10^3} = 1\times10^{-4} A$ $\quad \hookrightarrow I = 2\times10^{-4} + 1\times10^{-4}\, e^{-t/1}$

(confirmado!)

$I_{bateria} = \frac{10}{50\times10^{+3}} = 2\times10^{-4} A$ e $RC = 1,0\ s$

21)



a) • Não há corrente no circuito RC após estabilidade

logo, $I_3 = 0\ A$

• $R_{eq} = R_1 + R_2 = 12 + 15 = 27\ k\Omega$, A Intensidade é a do malha em R_1 e R_2

logo $I = \frac{\mathcal{E}}{R_{eq}} = \frac{9}{27 \times 10^3} = \frac{1}{3} \times 10^{-3}\ A \quad (\frac{1}{3}\ mA)$

b) O potencial em C é o mesmo que em R_2, não há corrente em R_3

$Q = C \Delta V = 10 \times 10^{-6} \times I R_2 = 10 \times 10^{-6} \times \frac{1}{3} \times 10^{-3} \times 15 \times 10^3$

$\Leftrightarrow Q = 5 \times 10^{-5}\ C$

c) $I = I_0\, e^{-t/RC}$ $\cancel{R_1}$

$\tau = (R_2 + R_3) C = 0{,}180\ s$

$I_0 = \frac{I R_2}{R_2 + R_3} = \frac{\frac{1}{3} \times 10^{-3} \times 15 \times 10^3}{18 \times 10^3} = 2{,}78 \times 10^{-4}\ A$

logo $I(t) = 2{,}78 \times 10^{-4} \times e^{-t/0{,}180}$ (A)

d) $\Delta V_f = \frac{1}{5} \Delta V \Rightarrow Q_f = C \times \frac{1}{5} \Delta V = 1 \times 10^{-5}\ C$

$Q_f(t) = Q_i\, e^{-t/0{,}180}$

$1 \times 10^{-5} = 5 \times 10^{-5}\, e^{-t/0{,}180}$

$\frac{1}{5} = e^{-t/0{,}180}$

$-\frac{t}{0{,}180} = \ln\left(\frac{1}{5}\right) \Leftrightarrow t = 0{,}290\ s$

5

22) $\varepsilon_r = 3$

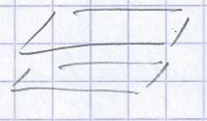
$E_{máx} = 2\times10^{8}\ V/m$

$C = 0{,}25\ \mu F$

$\Delta V_{máx} = 4000V$

$A = ?$

$C = \varepsilon_0 \times \varepsilon_r \times \frac{A}{d}$



$\Delta V = E d$

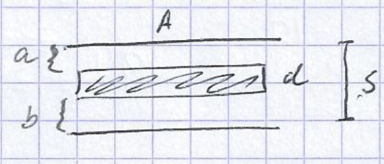
$4000 = 2\times10^{8} \times d \iff d = 2\times10^{-5}\ m$

logo

$0{,}25\times10^{-6} = 8{,}85\times10^{-12} \times 3 \times \frac{A}{2\times10^{-5}}$

$\iff A = 0{,}188\ m^2$

23) d, A } placa



s, A } condensador

Dois condensadores em série $\qquad a+d+b=s$

$$C = \frac{C_a \times C_b}{C_a + C_b} = \frac{\varepsilon_0 \frac{A}{a} \times \varepsilon_0 \frac{A}{b}}{\varepsilon_0 \frac{A}{a} + \varepsilon_0 \frac{A}{b}} = \frac{\varepsilon_0^2 A^2 \times \frac{1}{ab}}{\varepsilon_0 A \left(\frac{1}{a} + \frac{1}{b}\right)} =$$

$$= \varepsilon_0 A \times \frac{\frac{1}{\cancel{ab}}}{\frac{b+a}{\cancel{ab}}} = \frac{\varepsilon_0 A}{a+b} = \varepsilon_0 \frac{A}{s-d}$$

24) q_0

$+q$

$C_i = \varepsilon_0 \times \frac{A}{d} \qquad C_f = \varepsilon \varepsilon_0 \times \frac{A}{d}$

$Q = C\Delta V \iff \Delta V = \frac{Q}{C}$

$$\frac{q_0}{\cancel{\varepsilon_0} \frac{A}{d}} = \frac{q+q_0}{\varepsilon_r \cancel{\varepsilon_0} \times \frac{A}{d}} \iff \varepsilon_r = \frac{q+q_0}{q_0} \iff$$

$\iff \varepsilon_r = 1 + q/q_0$

25) $C = 3\ pF$

$\Delta V = 800V$

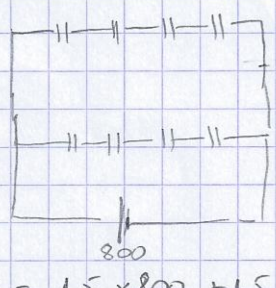
$C_i = 6pF$

$\Delta V_i = 200V$

$Q = C \times \Delta V = 2{,}4 \times 10^{-9}$

$Q_i = 6\times10^{-12} \times 200 = 1{,}2\times10^{-9}$

$\frac{\Delta V}{\Delta V_i} = 4 \qquad \frac{Q}{Q_1} = 2$



$C_{eq} = \left(\frac{1}{6} \times 4\right)^{-1} = 1{,}5$

$+ \qquad = 3$ ✓

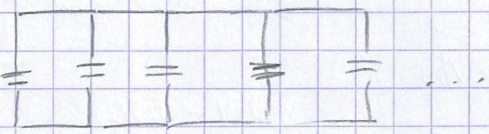
$C_{eq} = \left(\frac{1}{6} \times 4\right)^{-1} = 1{,}5$

$Q = 1{,}5\times800 + 1{,}5\times800 = 2{,}4\times10^{3}\ pC$ ✓

26) # condensadores = 10

$C = 500\mu F$

$\Delta V = 800V$



$C_{eq_i} = 10 \times 500 \times 10^{-6} = 5 \times 10^{-3}$ F

$Q = C\Delta V = 5 \times 10^{-3} \times 800 = 4$ C total $\Rightarrow \boxed{Q_i = 0{,}4C}$

para cada

série : $C_{eq} = \left(\frac{10}{500 \times 10^{-6}}\right)^{-1} = 5 \times 10^{-5}$ F

logo $\Delta V = \frac{Q}{C} = \frac{0{,}4}{5 \times 10^{-5}} = 8 \times 10^{3}$ V ✓