# Capítulo 4 - Capacidade

## Perguntas:

1) Opção E).
2) Opção C).
3) Opção A).
4) Opção D).
5) Opção C)

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

2) $\Delta V = 9V$ $\quad Q = 10^{10} \times (-1{,}602 \times 10^{-19}) = -1{,}602 \times 10^{9}$

$C = \frac{Q}{\Delta V} = \frac{|-1{,}602 \times 10^{9}|}{9} = 1{,}78 \times 10^{-10} F = 178 pF$

3) $C = \frac{KA}{4\pi kd} = \frac{1 \times 0{,}05^2 \times \pi}{4\pi \times 9 \times 10^9 \times 0{,}01} = 6{,}94 \times 10^{-12} F = 6{,}9 pF.$

4) $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2} \times \frac{Q^2 \times 4\pi kd}{KA}$

$\frac{U_f}{U_i} = \frac{\frac{1}{2} \times (9 \times 10^{-9})^2 \times 4\pi \times k \times 3 \times 10^{-3} \times KA}{\frac{1}{2} \times (3 \times 10^{-6})^2 \times 4\pi \times k \times 1 \times 10^{-3} \times KA} = 27$

## Problemas:

1) $P = 2kW = 2 \times 10^3 W$. $\quad \Delta t = 2 \times 10^{-3} s$ $\quad C = 50 \mu F = 50 \times 10^{-6} F$

a) $U = P \times \Delta t = 2 \times 10^3 \times 2 \times 10^{-3} = 4 J$ $\quad U = \frac{1}{2} Q \Delta V \Leftrightarrow$

$\Leftrightarrow U = \frac{1}{2} C \Delta V^2 \Leftrightarrow 4 = \frac{1}{2} \times 50 \times 10^{-6} \times \Delta V^2 \Leftrightarrow \Delta V^2 = 160\,000 \Leftrightarrow$

$\Leftrightarrow \Delta V = 400V$

b) $U = \frac{1}{2} C \Delta V^2 \Leftrightarrow 4 = \frac{1}{2} \times 250 \times 10^{-6} \times \Delta V^2 \Leftrightarrow \Delta V^2 = 32\,000 V \Leftrightarrow$
$\Leftrightarrow \Delta V = 179V$

c) O condensador de maior capacidade ocupa um volume maior.

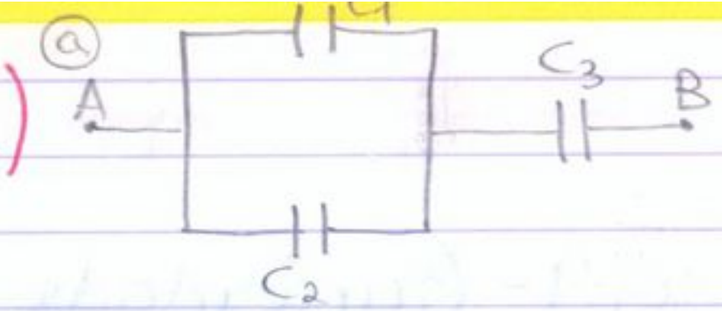
2) a) $r = 4 \times 10^{-2} m$ $\quad C = \frac{KR}{k} = \frac{4 \times 10^{-2}}{9 \times 10^9} = 4{,}44 \times 10^{-12} F = 4{,}44 pF$

b) $C_{esf} = \frac{KR_1R_2}{k(R_2 - R_1)} = \frac{5{,}6 \times 4 \times 10^{-2} \times 4{,}1 \times 10^{-2}}{9 \times 10^9 \times (4{,}1 \times 10^{-2} - 4 \times 10^{-2})} = 1{,}02 \times 10^{-9} F =$

$= 1{,}02 nF.$

c) $\frac{C_{esf}}{C_{cond.}} = \frac{1{,}02 \times 10^{-9} F}{4{,}44 \times 10^{-12} F} = 229{,}6$

3) a)




$C_4 = C_1 + C_2 = 1,2 + 4,3 = 5,5\,\mu F$ $\quad C_5 = \left(\frac{1}{C_4} + \frac{1}{C_3}\right)^{-1} = \left(\frac{1}{5,5} + \frac{1}{0,5}\right)^{-1} = 1,72\,\mu F$

$Q_5 = C_5 \Delta V = 1,72 \times 10^{-6} \times 9 = 1,548 \times 10^{-5}\,C = Q_3 = Q_4$

$\Delta V_4 = \frac{Q_4}{C_4} = \frac{1,548 \times 10^{-5}}{5,5 \times 10^{-6}} = 2,8\,V$ $\quad Q_1 = C_1 \Delta V_4 = 1,2 \times 10^{-6} \times 2,8 = 3,36 \times 10^{-6}\,C$

$Q_2 = C_2 \Delta V_4 = 4,3 \times 10^{-6} \times 2,8 = 1,204 \times 10^{-5}\,C$ R: $Q_1 = 3,36\,\mu C$; $Q_2 = 12\,\mu C$

$Q_3 = 15,5\,\mu C$.

b) $U_5 = \frac{1}{2} Q_5 \Delta V = \frac{1}{2} \times 1,548 \times 10^{-5} \times 9 = 6,966 \times 10^{-5}\,J = 69,7\,\mu J$

4) $C_1 = \frac{K_1 A}{4\pi K d} = \frac{4,9 \times 12 \times 10^{-4}}{4\pi \times 9 \times 10^9 \times 0,5 \times 10^{-2}} = 1,04 \times 10^{-11}\,F$

$C_2 = \frac{K_2 A}{4\pi K d} = \frac{5,6 \times 12 \times 10^{-4}}{4\pi \times 9 \times 10^9 \times 0,5 \times 10^{-2}} = 1,2 \times 10^{-11}\,F$

$C_{total} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1} = \left(\frac{1}{1,04 \times 10^{-11}} + \frac{1}{1,2 \times 10^{-11}}\right)^{-1} = 5,57 \times 10^{-12}\,F = 5,57\,pF$

5) a) $A = 93\,m^2$ $\quad r = 0,5 \times 10^{-2}\,m$ $\quad K_{ceramico} = 3,4$ $\quad \Delta V_i = 12\,V$

$W = U_f - U_i = \frac{1}{2} Q_f \Delta V_f - \frac{1}{2} Q_i \Delta V_i = \frac{1}{2} C_f \Delta V_f^2 - \frac{1}{2} C_i \Delta V_i^2$

$C_i = \frac{KA}{4\pi K d} = \frac{3,4 \times 0,3}{4\pi \times 9 \times 10^9 \times 0,5 \times 10^{-2}} = 1,804 \times 10^{-9}\,F$

$C_f = \frac{KA}{4\pi K d} = \frac{0,3}{4\pi \times 9 \times 10^9 \times 0,5 \times 10^{-2}} = 5,305 \times 10^{-10}\,F$

$Q_i = Q_f \Leftrightarrow C_i \Delta V_i = C_f \Delta V_f \Leftrightarrow \Delta V_f = \frac{C_i \Delta V_i}{C_f} = \frac{1,804 \times 10^{-9} \times 12}{5,305 \times 10^{-10}} = 40,807\,V$

$W = \frac{1}{2} \times 5,305 \times 10^{-10} \times 40,807^2 - \frac{1}{2} \times 1,804 \times 10^{-9} \times 12^2 \Leftrightarrow$

$\Leftrightarrow W = 3,12 \times 10^{-7}\,J$

$d = 0,5\,cm = 5\,mm$

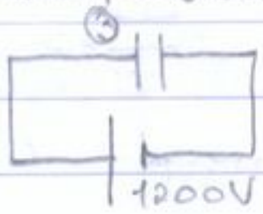
b) $V_{max} = E_{max} d$ $\quad E_{max\,(ceramico)} = 40\,kV/mm$

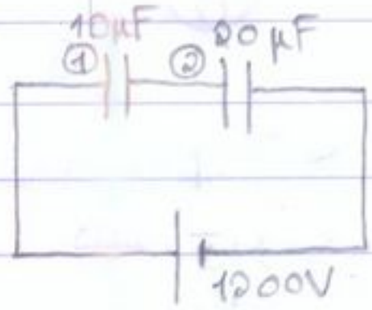
Com dielétrico: $V_{max} = 40 \times 5 = 200\,kV$

Sem dielétrico: $V_{max} = 3 \times 5 = 15\,kV$

$(E_{max\,(ar\ puro)} = 3)$

Circuito simplificado:



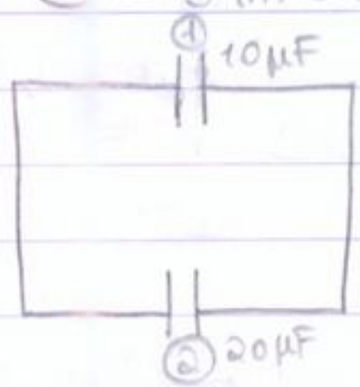




6) a)

$\Delta V_3 = 1200\,V \qquad C_3 = \left(\frac{1}{10}+\frac{1}{20}\right)^{-1} = 6{,}67\,\mu F = 6{,}67\times10^{-6}\,F$

$Q_3 = C_3 \times \Delta V_3 = 6{,}67\times10^{-6}\times1200 = 8\times10^{-3}\,C = 8\,mC = Q_1 = Q_2$

b) Os dois condensadores estão agora em paralelo.




$C_3 = C_1 + C_2 = 10+20 = 30\,\mu F = 30\times10^{-6}\,F$

circuito equivalente:

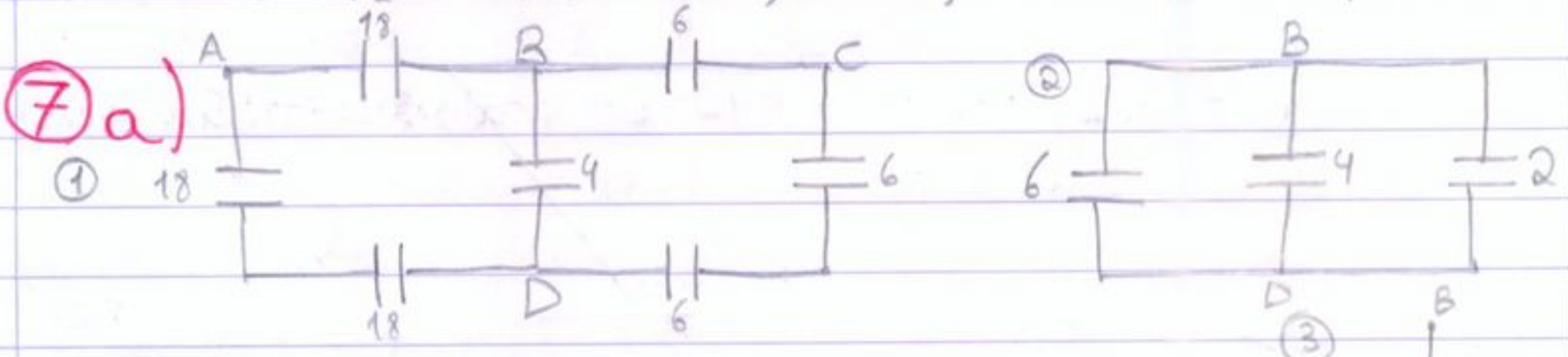

$Q_3 = Q_1 + Q_2 = 2\times8\times10^{-3} = 0{,}016\,C$

$\Delta V_3 = \frac{Q_3}{C_3} = \frac{0{,}016}{30\times10^{-6}} = 533{,}33\,V = \Delta V_1 = \Delta V_2$

$Q_1 = C_1 \Delta V_1 = 10\times10^{-6}\times533{,}33 = 0{,}00533\,C = 5{,}33\,mC$

$Q_2 = C_2 \Delta V_2 = 20\times10^{-6}\times53333 = 0{,}01067\,C = 10{,}67\,mC.$

7) a)

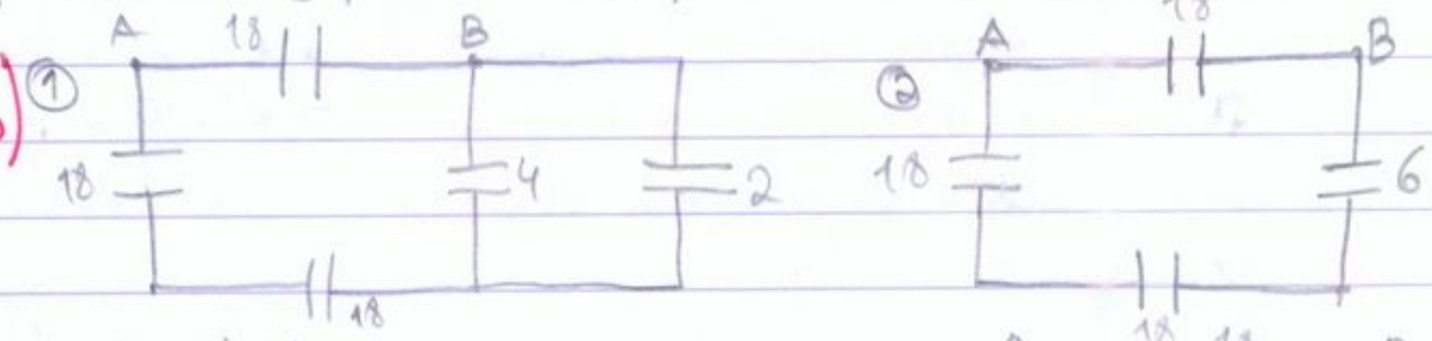



C → pF

$\left(\frac{1}{18}+\frac{1}{18}+\frac{1}{18}\right)^{-1} = 6\,pF \qquad \left(\frac{1}{6}+\frac{1}{6}+\frac{1}{6}\right)^{-1} = 2\,pF$

R: 12 pF $\qquad 6+4+2 = 12\,pF$

b)




$\left(\frac{1}{6}+\frac{1}{6}+\frac{1}{6}\right)^{-1} = 2\,pF \qquad 4+2 = 6\,pF$

$\left(\frac{1}{18}+\frac{1}{18}+\frac{1}{6}\right)^{-1} = 3{,}6\,pF$

$18+3{,}6 = 21{,}6\,pF$

R: 21,6 pF

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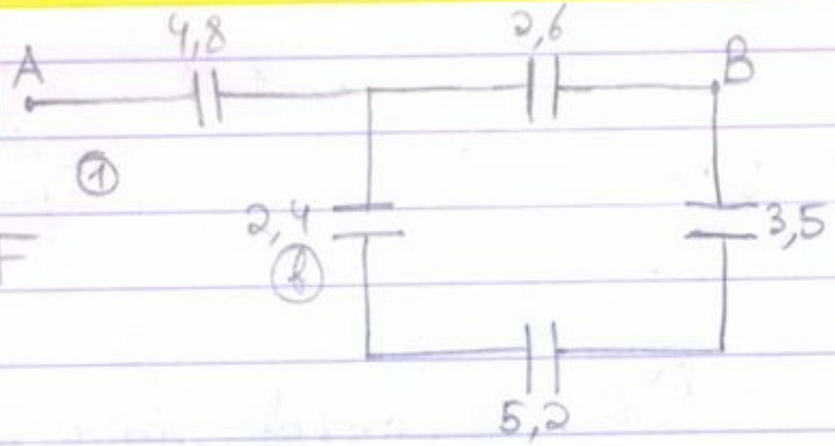
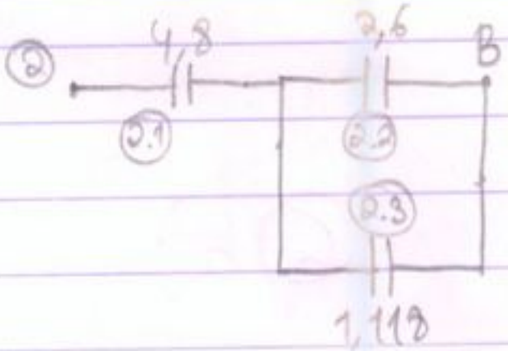
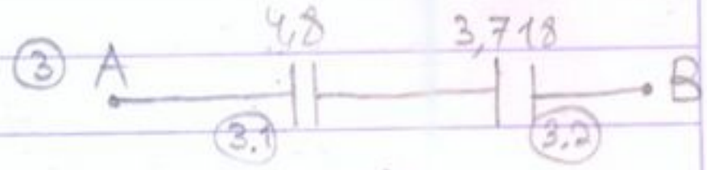
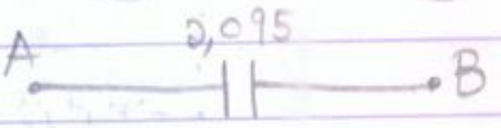



C → pF




$\left(\frac{1}{2,4}+\frac{1}{5,2}+\frac{1}{3,5}\right)^{-1}=1,118pF$




$2,6+1,118=3,718pF$ $\left(\frac{1}{4,8}+\frac{1}{3,718}\right)^{-1}=2,095pF$

$Q_{④}=C_{④}\times\Delta V_{④}=2,095\times10^{-12}\times5=1,0475\times10^{-11}C=Q_{3.1}=Q_{3.2}$

$\Delta V_{2.3}$ // $\Delta V_{3.1}=\frac{Q_{3.1}}{C_{3.1}}=\frac{1,0475\times10^{-11}}{4,8\times10^{-12}}=2,1823V$ $\Delta V_{3.2}=\frac{Q_{3.2}}{C_{3.2}}=\frac{1,0475\times10^{-11}}{3,718\times10^{-12}}=2,8174V$

$Q_{2.3}=C_{2.3}\times\Delta V_{2.3}=1,118\times10^{-12}\times2,8174=3,15\times10^{-12}C$

$Q_{⑧}=Q_{2.3}=3,15\times10^{-12}C=3,15\,pC$