Folha 5

1)

a. $T = \frac{9}{5} \times (-71) + 32 \approx -95,8\ °F$

b. $T_f = \frac{9}{5} T_c + 32 \Rightarrow T_c = \frac{5}{9}(T_F - 32) = \frac{5}{9}(134 - 32) = 56,7\ °C$

c. $T_{Sibéria} = T_c + 273,15 = -71 + 273,15 = 202,15\ K$

$T_{Califórnia} = T_c + 273,15 = 56,7 + 273,15 = 329,85\ K$

2)

a. $V = A \times \ell$ $\quad \Delta T = 100 - 0 = 100°C$ $\quad \rho = \frac{m}{V} \rightarrow m$ constante $\quad$ material isotrópico $\rightarrow (\beta = 3\alpha)$

$\Delta\rho = \Delta\left(\frac{m}{V}\right) = m \times \Delta\left(\frac{1}{V}\right) = m\left(\frac{1}{V_f} - \frac{1}{V_i}\right) = m\left(\frac{V_i - V_f}{V_f V_i}\right) = -\frac{m}{V_f V_i}\Delta V = -\rho\frac{\Delta V}{V_i} = -\rho\, 3\frac{\Delta L}{L}$

$\frac{\Delta\rho}{\rho} = -3\frac{\Delta L}{L} = -3(0,23) = -0,69\%$

b. $\Delta\rho = -\alpha(T_f - T_i) = -100\alpha = -23\% \rightarrow$ Alumínio

3) $\ell = 2 \times 10^3\ m$ $\quad \Delta T = 40°C \rightarrow \Delta T = 40\ K$ $\quad \alpha = 1,27 \times 10^{-5}\ K^{-1}$

$\Delta L = \ell\, \alpha\, \Delta T = 2 \times 10^3 \times 1,27 \times 10^{-5} \times 40 \approx 1,02\ m$

4) $V = (5,0 \times 10^{-2})(10 \times 10^{-2})(6,0 \times 10^{-2}) = 3,0 \times 10^{-4}\ m^3$ $\quad \alpha = 1,0 \times 10^{-5}\ °C^{-1}$

$\Delta T = 47 - 15 = 32\ °C$ $\quad \beta = 3\alpha = 3 \times 1,0 \times 10^{-5} = 3,0 \times 10^{-5}\ °C^{-1}$

$\Delta V = V \beta \Delta T = (3,0 \times 10^{-4})(3,0 \times 10^{-5}) \times 32 = 2,88 \times 10^{-7}\ m^3$

5) $m_b = 0,05\ kg$ $\quad T_b = 200°C$ $\quad m_{água} = 0,4\ kg$ $\quad T_{água\,i} = 20°C$

$T_f = 22,4\ °C$ $\quad c_{água} = 4186\ J/(kg\,°C)$

$Q = c\, m\, \Delta T$ $\quad Q_b = c_b \times 0,05(22,4 - 200) = -8,88\, c_b\ J$

$Q_{água} = 4186 \times 0,4(22,4 - 20) = 4018,56\ J$ $\quad$ Equilíbrio térmico: $Q_{água} = -Q_b$

$4018,56 = -(-8,88\, c_b) \Rightarrow c_b = \frac{4018,56}{8,88} \approx 452,54\ J/(kg\,°C)$

6) $m = 10\ kg$ $\quad T_i = -10°C$ $\quad T_i(K) = -10 + 273,15 = 263,15\ K$

$T_f = 0°C$ $\quad T_f(K) = 0 + 273,15 = 273,15\ K$

$Q = c\, m\, \Delta T + m\, L = 0,500 \times 10(273,15 - 263,15) + (10 \times 10^3 \times 79,7) \times 10^{-3}$
$= 50 + 797 = 847\ kcal$

7) $M = 6,0\ kg$ $h_1 = 2,0\ m$ 25 vezes $m_{agua} = 500\ g$ $\Delta T = 1,4^\circ C$

$W = E_p = mgh = 25(6,0 \times 9,8 \times 2,0) = 2940\ J$

$Q = m\, c_{agua}\, \Delta T = 500 \times 1 \times 1,4 = 700\ cal$

$700\ cal \longrightarrow 2940\ J$ $x = \dfrac{1 \times 2940}{700} = 4,2\ J$

$1\ cal \longrightarrow x\ J$

8) $q = \dfrac{\Delta Q}{\Delta t}$ e $q = K A \dfrac{\Delta T}{l}$ $\Big\}$ $\dfrac{\Delta Q}{\Delta t} = K A \dfrac{\Delta T}{l}$

$A = (10 \times 10^{-3})(10 \times 10^{-3}) = 1 \times 10^{-4}\ m^2$ $\Delta T = 5^\circ C$

$K = 150\ W m^{-1} {}^\circ C^{-1}$ $l = 1,0 \times 10^{-3}\ m$

$\dfrac{\Delta Q}{\Delta t} = 150 \times 1 \times 10^{-4} \times \dfrac{5}{1,0 \times 10^{-3}} = 75\ W$

9) $T_{pele} = 30^\circ C$ $T_{ar} = 0^\circ C$

$\dfrac{\Delta Q}{\Delta t} = h A \Delta T = (1,7 \times 10^{-3}) \times (1,5) \times [(30 + 273,15) - (0 + 273,15)] = 76,5\ cal\ s^{-1}$

$1\ cal \to 4,2\ J$ $x = \dfrac{4,2 \times 76,5}{1} \approx 321,3\ J$

$76,5\ cal \to x$

$\dfrac{\Delta Q}{\Delta t} = \dfrac{321,3}{1} = 321,3\ W$

10) $K = 10^{-4}\ cal\ s^{-1}\ cm^{-1}\ K^{-1}$ $l = 5,0\ cm$ $T_1 = 5,0 + 273,15 = 278,15\ K$

$A = 2,0\ m^2 \to A = 2,0 \times 10^4\ cm^2$ $T_2 = 20,0 + 273,15 = 293,15\ K$

$\dfrac{\Delta Q}{\Delta t} = K A \dfrac{\Delta T}{l} = 10^{-4}(2,0 \times 10^4)\dfrac{(293,15 - 278,15)}{5,0} = 6\ cal\ s^{-1}$

$1\ h = 3600\ s$ $\Delta Q = 6 \times 3600 = 21600\ cal$

$Q = mc\Delta T + m L_f \to m = \dfrac{Q}{c\Delta T + L_f} = \dfrac{21600}{1 \times 5 + 79,7} \approx 255,02\ g$

11) $l_1 = 2,0\ cm$ $K_1 = 0,12\ cal\ s^{-1} cm^{-1} {}^\circ C^{-1}$ $T_1 = 100^\circ C$

$l_2 = 7\ cm$ $K_2 = 0,49\ cal\ s^{-1} cm^{-1} {}^\circ C^{-1}$ $T_2 = 20^\circ C$

$\dfrac{q_1}{A} = \dfrac{q_2}{A} = \dfrac{q}{A}$ $q_1 = \dfrac{\Delta Q_1}{\Delta t}$ e $q_2 = \dfrac{\Delta Q_2}{\Delta t}$

$(T_{face} - T_2) = \dfrac{K_1\, \Delta x_2}{K_2\, \Delta x_1}(T_1 - T_{face}) = \dfrac{K_1\, \Delta x_2}{K_2\, \Delta x_1} T_1 - \dfrac{K_1\, \Delta x_2}{K_2\, \Delta x_1} T_{face}$

$$T_{face}\left(1+\frac{K_1\Delta x_2}{K_2\Delta x_1}\right)=\frac{K_1\Delta x_2}{K_2\Delta x_1}T_1+T_2 \Rightarrow T_{face}=\frac{\frac{K_1\Delta x_2}{K_2\Delta x_1}T_1+T_2}{1+\frac{K_1\Delta x_2}{K_2\Delta x_1}}=\frac{\frac{0,12\times 7}{0,49\times 2}\times 100+20}{1+\frac{0,12\times 7}{0,49\times 2}}\approx 56,92\ ^\circ C$$

12) $$q=\frac{\Delta Q}{\Delta t}=\frac{50}{100}\times 50\times 100=2500\ Kcal/h \rightarrow \frac{2500\times 10^3}{3600}\ cal\ s^{-1}$$

$$q=\frac{\Delta Q}{\Delta t}=KA\frac{\Delta T}{\Delta x}\Rightarrow \Delta T=\frac{\Delta Q}{\Delta t}\times\frac{\Delta x}{KA}=\frac{2500\times 10^3}{3600}\times\frac{1,0\times 10^{-2}}{0,2\times 10,0}\approx 3,47\ K$$

$$\Delta T(^\circ C)=\Delta T(K)\rightarrow T_{sala}=T_{ex}+3,47=15+3,47\approx 18,5\ ^\circ C$$

13)

a. $$R_{vidro}=\frac{\Delta x}{KA}=\frac{0,5\times 10^{-2}}{0,80\times 1,0}=6,25\times 10^{-3}\ ^\circ C/W$$

$$R_{vidro\ duplo}=R_{vidro}\times 2+R_{ar}=2\times 6,25\times 10^{-3}+\left(\frac{0,15\times 10^{-2}}{0,025\times 1,0}\right)=7,25\times 10^{-2}\ ^\circ C/W$$

$$\frac{R_{vidroduplo}}{R_{vidro}}=\frac{7,25\times 10^{-2}}{6,25\times 10^{-3}}\approx 12$$

b. $$R_e=R_{vidro}+R_{ext}+R_{int}$$

$$R_{int}=\frac{3,0\times 10^{-3}}{0,025\times 1,0}=0,12\ ^\circ C/W$$

$$R_{ext}=\frac{1,5\times 10^{-3}}{0,025\times 1,0}=0,06\ ^\circ C/W$$

Vidro simples:

$$R_e=6,25\times 10^{-3}+0,12+0,06\approx 0,19\ ^\circ C/W$$

Vidro duplo:

$$R_e=7,25\times 10^{-2}+0,12+0,06\approx 0,25\ ^\circ C/W$$

14) Lei de Stefan-Boltzmann:

$$P=\varepsilon\sigma AT^4\Rightarrow T=\sqrt[4]{\frac{P}{\varepsilon\sigma A}}=\sqrt[4]{\frac{3,9\times 10^{26}}{1\times(5,6697\times 10^{-8})\times 4\pi(7,0\times 10^8)^2}}\approx 5,78\times 10^3\ K$$

15) $$P_{sol}=\varepsilon\sigma A_{sol}T_{sol}^4=1\times(5,6697\times 10^{-8})\times(4\pi R_{sol}^2)\times(6000)^4$$

$$I=\frac{P_{sol}}{4\pi d^2}=\frac{P_{Terra}}{\pi R_{Terra}^2}\Rightarrow\frac{(5,6697\times 10^{-8})\times\cancel{4\pi}R_{sol}^2\times 6000^4}{\cancel{4\pi}d^2}=\frac{1\times\cancel{(5,6697\times 10^{-8})}\times 4\cancel{\pi}\cancel{R_{Terra}^2}\times T^4}{\cancel{\pi}\cancel{R_{Terra}^2}}$$

$$4T^4=\frac{(6,96\times 10^8)^2\times 6000^4}{(1,49\times 10^{11})^2}\Rightarrow T=\sqrt[4]{\frac{(6,96\times 10^8)^2\times 6000^4}{4\times(1,49\times 10^{11})^2}}\approx 289,97\ K$$

16)

a. $T(^\circ C)=35\ ^\circ C\rightarrow T(K)=35+273,15=308,15\ K$

Segundo a Lei de Wein: $$\lambda_{max}=\frac{2,898\times 10^{-3}}{308,15}\approx 9,405\times 10^{-6}\ m=9405\ nm$$

b. $T_{céu} = -5\,°C$

$$P = \varepsilon \sigma A (T_{corpo}^4 - T_{céu}^4) = 0,9\,(5,6697\times10^{-8}) \times 0,9 \times \left[(35+273,15)^4 - (-5+273,15)^4\right] \approx 176,65\ W$$

c. $P = 50\ W$

$$T_{meio} = 273,15 - 5 = 268,15\ K$$

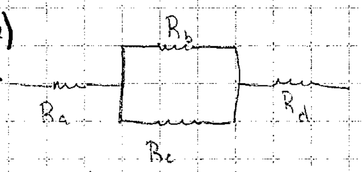
$$P = \varepsilon \sigma A (T^4 - T_{meio}^4) \Leftrightarrow 50 = 0,9 \times 5,6697\times10^{-8} \times 0,9 \times (T^4 - (268,15)^4)$$

$$\Rightarrow T^4 = \frac{50}{0,9\times5,6697\times10^{-8}\times0,9} + (268,15)^4 \Rightarrow T = \sqrt[4]{\frac{50}{0,9\times5,6697\times10^{-8}\times0,9} + (268,15)^4} \approx 281,27\ K$$

$$T(°C) = T(K) - 273,15 = 281,27 - 273,15 \approx 8\,°C$$

17)

a.




$$R_T = R_a + \left[\left(\frac{1}{R_b} + \frac{1}{R_c}\right)\right]^{-1} + R_d$$

$$R_a = \frac{\Delta x}{K_a A} = \frac{2,5\times10^{-2}}{175\times(1,5)^2} \approx 6,35\times10^{-5}\ Kw^{-1} \qquad R_b = \frac{7,5\times10^{-2}}{40\times\frac{(1,5)^2}{2}} \approx 1,67\times10^{-3}\ Kw^{-1}$$

$$R_c = \frac{7,5\times10^{-2}}{50\times\frac{1,5^2}{2}} \approx 1,33\times10^{-3}\ Kw^{-1} \qquad R_d = \frac{5,0\times10^{-2}}{80\times(1,5)^2} \approx 2,78\times10^{-4}\ Kw^{-1}$$

$$R_T = 6,35\times10^{-5} + \left[\left(\frac{1}{1,67\times10^{-3}} + \frac{1}{1,33\times10^{-3}}\right)\right]^{-1} + 2,78\times10^{-4} \approx 1,08\times10^{-3}\ Kw^{-1}$$

b. $$q = KA\frac{\Delta T}{\Delta x} = \frac{\Delta T}{R_T} = \frac{(370-(-10))}{1,08\times10^{-3}} \approx 351,9\ KW$$

c. $$q_{a-c} = \frac{\Delta T_{a-c}}{R_a} = \frac{370 - T_{a-c}}{6,35\times10^{-5}} \rightarrow T_{a-c} = -6,35\times10^{-5}\times351,9\times10^3 + 370 \approx 347,7\,°C$$

$$q_{b-d} = \frac{\Delta T_{b-d}}{Rd} = \frac{T_{b-d} - (-10)}{2,78\times10^{-4}} \rightarrow T_{b-d} = 2,78\times10^{-4}\times351,9\times10^3 + 10 \approx 87,8\,°C$$

18)

a. $$R_T = R_{pedra} + R_{espuma} + R_{madeira} = 4,29\times10^{-2} + 2 + 1,43\times10^{-1} \approx 2,19\ Kw^{-1}$$

$$R_{pedra} = \frac{\Delta x}{KA} = \frac{15\times10^{-2}}{3,5\times1} \approx 4,29\times10^{-2}\ Kw^{-1} \qquad R_{madeira} = \frac{2\times10^{-2}}{0,14\times1} \approx 1,43\times10^{-1}\ Kw^{-1}$$

$$R_{espuma} = \frac{5\times10^{-2}}{0,025\times1} = 2\ Kw^{-1}$$

b. $$q = \frac{\Delta T}{R_T} = \frac{35-20}{2,19} \approx 6,85\ W$$

c. $$T_{p-e} = -R_p \times q + Text = -4,29\times10^{-2}\times6,85 + 35 \approx 34,7\,°C$$

$$T_{e-m} = R_m \times q + Tint = 1,43\times10^{-1}\times6,85 + 20 \approx 21,0\,°C$$

19)

a. $R_T = R_{cu} + R_{al} = \dfrac{3{,}0 \times 10^{-2}}{401 \times (3{,}0 \times 10^{-2})^2} + \dfrac{3{,}0 \times 10^{-2}}{237 \times (3{,}0 \times 10^{-2})^2} \approx 223{,}8 \times 10^{-3}\ K/W$

b. $q = \dfrac{\Delta T}{R_T} = \dfrac{100-20}{223{,}8 \times 10^{-3}} \approx 357{,}46\ W$

c. $T_{interface} = -R_{cu} \times q + T_{ext} = -8{,}31 \times 10^{-2} \times 357{,}46 + 100 \approx 70{,}3°$

20)

a. $R_1 = \dfrac{3 \times 10^{-2}}{50 \times 1} = 6 \times 10^{-4}\ K/W$ $\qquad R_2 = \dfrac{5 \times 10^{-2}}{30 \times 1} \approx 1{,}67 \times 10^{-3}\ K/W$

$R_3 = \dfrac{7 \times 10^{-2}}{15 \times 1} \approx 4{,}67 \times 10^{-3}\ K/W$

b. $q = \dfrac{\Delta T}{R_T} = \dfrac{100-20}{(6 \times 10^{-4}) + (1{,}67 \times 10^{-3}) + (4{,}67 \times 10^{-3})} = 11{,}53 \times 10^{3}\ W$

c. O 1º material, pois tem menor resistência

21)

a. $R_T = \dfrac{1 \times 10^{-2}}{0{,}12 \times 0{,}75} + \dfrac{2 \times 10^{-2}}{0{,}10 \times 0{,}75} \approx 0{,}378\ K\,W^{-1}$

$q = \dfrac{\Delta T}{R_T} = \dfrac{(30+273{,}15)-(0+273{,}15)}{0{,}378} \approx 79{,}37\ W$

b. $q = \dfrac{\Delta T}{R_{madeira}} \Rightarrow \Delta T = q\, R_{mad} \Leftrightarrow (30+273{,}15) - (T_{sup} + 273{,}15) = 79{,}37 \times \dfrac{1 \times 10^{-2}}{0{,}12 \times 0{,}75}$

$T_{sup} = \left(30 + 273{,}15 - 79{,}37 \times \dfrac{1 \times 10^{-2}}{0{,}12 \times 0{,}75}\right) - 273{,}15 \approx 21{,}18\ °C$

c. $q = \dfrac{\Delta Q}{\Delta t} = \dfrac{c\, m\, \Delta T}{\Delta t} \rightarrow \Delta t = \dfrac{c\, m\, \Delta T}{q} = \dfrac{3{,}34 \times 10^{5} \times 2{,}5}{79{,}37} \approx 10520{,}35\ s$

$1\,h \longrightarrow 3600\ s$

$x \longrightarrow 10520{,}35\ s$

$x = \dfrac{10520{,}35 \times 1}{3600} \approx 3$ horas

22) $\boxed{E = P\,\Delta t}$

a. $E = \varepsilon \sigma A (T_{corpo}^4 - T_{ext}^4) \times \Delta t = 0{,}90 \times (5{,}6697 \times 10^{-8}) \times 1{,}85 ((37+273{,}15)^4 - (22+273{,}15)^4) \times (15 \times 60) \approx 141{,}40 \times 10^{3}\ J$

b. $R = \dfrac{\Delta x}{K A} = \dfrac{2{,}5 \times 10^{-2}}{0{,}13 \times 0{,}80} \approx 0{,}240\ K/W$

c. $45\% \rightarrow 15\ min$ $\qquad P = \dfrac{0{,}45 \times 141{,}40 \times 10^{3}}{15 \times 60} = 70{,}7\ W$

$q = \dfrac{\Delta T}{R_T} \Rightarrow (37 + \cancel{273{,}15}) - (T + \cancel{273{,}15}) = 70{,}7 \times 0{,}240 \Rightarrow T = 37 - 70{,}7 \times 0{,}240 \approx 20{,}03\ °C$