111.

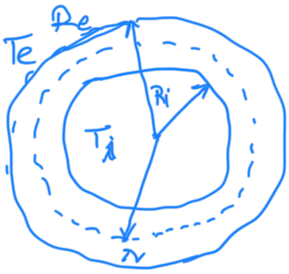
$\ell = 35\,m$

$R_i = 2.5\,m \quad , R_e = R_i + 6\,cm$

$K = 4\times10^{-5}\ cal/s\,cm\,°C$

$T_i = 25°C$

$T_e = -40°C \qquad \dfrac{dQ}{dt} = -KA\dfrac{dT}{dr}$



Em qualquer superfície cilíndrica de raio r (e altura ℓ) o fluxo de calor $\dfrac{dQ}{dt}$ é constante.

$$\frac{dQ}{dt} = -K\,2\pi r\,\ell\,\frac{dT}{dr} = C_1 \qquad , C_1 = cte$$

$$\frac{dT}{dr} = -\frac{\tilde{C}_1}{r} \qquad , \left(\tilde{C}_1 = \frac{C_1}{K2\pi\ell}\right)$$

$$T(r) = -\tilde{C}_1 \ln(r) + C_2$$

$$T(r=R_i) = -\tilde{C}_1 \ln(R_i) + C_2 = T_i$$
$$T(r=R_e) = -\tilde{C}_1 \ln(R_e) + C_2 = T_e$$

$$-\tilde{C}_1[\ln(R_i) - \ln(R_e)] = T_i - T_e \quad \rightarrow \quad \tilde{C}_1 = \frac{T_i - T_e}{\ln(R_e/R_i)}$$

$$\frac{dQ}{dt} = \tilde{C}_1 \times K2\pi\ell = K2\pi\ell\,\frac{(T_i - T_e)}{\ln(R_e/R_i)} \simeq 10\ kW$$

[Analogia com as resistências eléctricas: $I = \dfrac{\Delta V}{R} \longleftrightarrow \dfrac{dQ}{dt} = \dfrac{\Delta T}{R_t}$

$$R_t = \frac{\ln(R_e/R_i)}{2\pi K\ell}$$]

— n —

113.

$dQ(r) = \gamma^2 \sigma \pi r^2$

dt

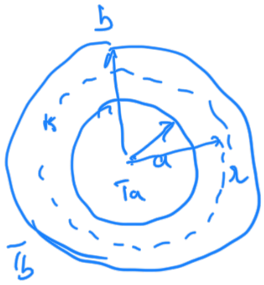
112.

$$\left[\, dQ = -mc\,dT \,\right]$$

$$\frac{dQ}{dt} = -mc\frac{dT}{dt} = \frac{T - T_e}{R_t} \quad ; \quad T \equiv T_i(t)$$

Assumimos que o fluxo de calor $\frac{dQ}{dt}$ se estabelece a partir dos valores instantâneos de T_i e T_e muito rapidamente (numa escala de tempo muito mais curta que a escala de tempo de variação do T_i).

109.



Em qualquer superfície esférica de raio r, o fluxo de calor é constante.

$$\frac{dQ}{dt} = -KA\frac{dT}{dr} = -K\,4\pi r^2\frac{dT}{dr} = C_1$$

$$\frac{dT}{dr} = -\frac{\tilde{C}_1}{r^2} \qquad \tilde{C}_1 = \frac{C_1}{4\pi K}$$

$$T(r) = \frac{\tilde{C}_1}{r} + C_2 \quad ; \quad T(r=a) = T_a = \frac{\tilde{C}_1}{a} + C_2$$

$$T(r=b) = T_b = \frac{\tilde{C}_1}{b} + C_2$$

$$T_b - T_a = \tilde{C}_1\left[\frac{1}{b} - \frac{1}{a}\right]$$

$$T_b - T_a = \tilde{C}_1\frac{(a-b)}{ab},$$

$$\tilde{C}_1 = \frac{ab}{(a-b)}(T_b - T_a) \quad ; \quad \frac{dQ}{dt} = \tilde{C}_1\,4\pi K = \frac{ab\,(T_b - T_a)}{(a-b)}4\pi K$$

$$= \frac{ab}{b-a}(T_a - T_b)\,4\pi K$$

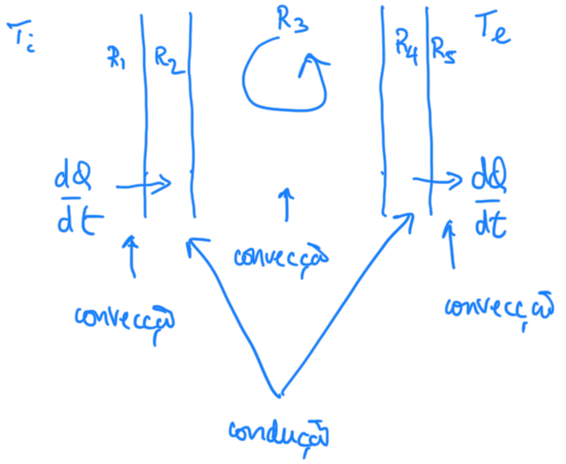
— n —

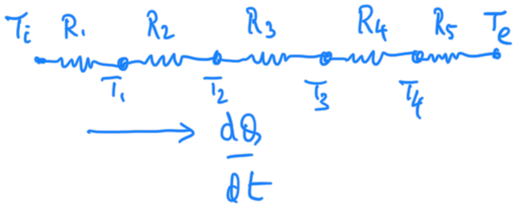
108.

$T_i = 22°C$ $\qquad l_a = 1$ cm $\qquad h_i = 8\ W/m^2\,°C$

$T_e = 12\,°C$ ... $h_e = 25\ W/m^2°C$

$A = 1\,m^2$ $\quad K_v = 0{,}8\ W/m°C$ $\quad h_a = 7\ W/m^2°C$



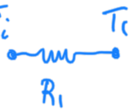


a) $\dfrac{dQ}{dt} = \dfrac{\Delta T}{R_{tot}}$, $R_{tot} = R_1 + R_2 + \cdots + R_5$

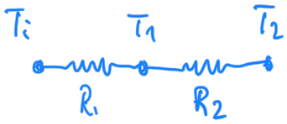
$R_1 = \dfrac{1}{h_i A} = 0{,}125\ K/W$; $R_2 = \dfrac{l_v}{K_v A} = 0{,}005\ K/W = R_4$

$R_3 = \dfrac{1}{h_a A} \simeq 0{,}143\ K/W$; $R_5 = \dfrac{1}{h_e A} = 0{,}04\ K/W$; $R_t = 0{,}318\ K/W$

$\dfrac{dQ}{dt} = \dfrac{(22-12)}{0{,}318} \simeq 31{,}45\ W$

b) 

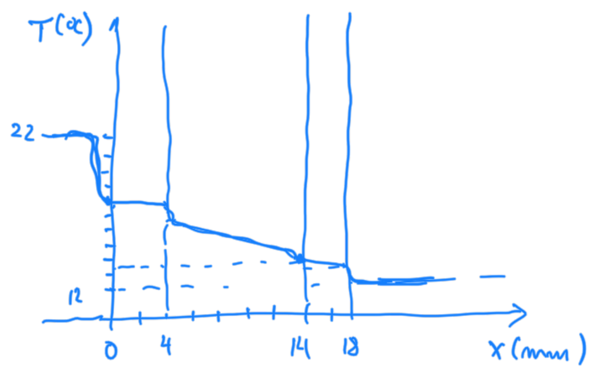
$\dfrac{dQ}{dt} = \dfrac{T_i - T_1}{R_1}$; $T_1 = T_i - R_1\left(\dfrac{dQ}{dt}\right) = 18{,}07\,°C$



$\dfrac{dQ}{dt} = \dfrac{T_i - T_2}{R_1 + R_2}$; ou $\dfrac{dQ}{dt} = \dfrac{T_1 - T_2}{R_2}$

ou ....

$T_2 = 17{.}91\,°C$; $T_3 = 13{.}41\,°C$, $T_4 = 13{,}26\,°C$



c) $A' = 0{,}1 A = 0{,}1\,m^2$

$l = 2{,}5\,cm$ $\quad K = 5\ W/m°C$

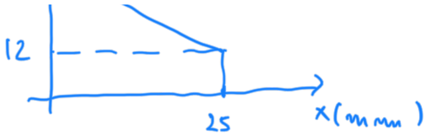
$\dfrac{dQ}{dt} = -KA'\dfrac{dT}{dx} = -KA'\dfrac{\Delta T}{l}$

$= 200\ W$ $\left[R_t = \dfrac{l}{KA'}\right]$

d) 

e) 

$\dfrac{dQ}{dt} = \dfrac{dQ_1}{dt} + \dfrac{dQ_2}{dt}$



$$= \frac{(T_i - T_e)}{R_{a)}} + \frac{(T_i - T_e)}{R_{c)}} =$$

$$= (T_i - T_e)\left[\frac{1}{R_{a)}} + \frac{1}{R_{c)}}\right] = \frac{(T_i - T_e)}{R}$$

→ Associação em paralelo!

97.

P a 3000 m? $P = P_0 - \rho g h$

ou (atmosfera isotérmica) $P = P_0 \exp\left(-\frac{mgz}{kT}\right)$

ou (....)

$$\frac{dP}{dT} = \frac{\lambda}{T(v_v - v_\ell)} \qquad \frac{\Delta P}{\Delta T} \approx \frac{\lambda}{T_0(v_v - v_\ell)} \quad \text{ou}$$

integrar para a transição líquido-vapor:

$$v_v \gg v_\ell \qquad \frac{dP}{dT} \approx \frac{m\lambda}{T V_v} = \frac{m\lambda}{T n R T} P = \left(\frac{m}{n}\right)\frac{\lambda P}{RT^2}$$

$$\frac{dP}{P} = \left(\frac{m}{n}\right)\frac{\lambda}{R}\frac{dT}{T^2} \rightarrow \int_i^f \frac{dP}{P} = \left(\frac{m}{n}\right)\frac{\lambda}{R}\int_i^f \frac{dT}{T^2} \quad (\ldots)$$

98. Ver no compêndio :)