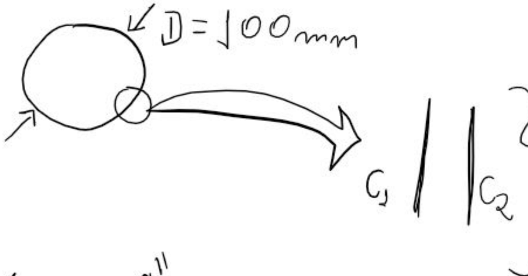
# Solução da Lista 4

## Questão 01

Dados → • 10 bars, 27°C • $L = 2\ mm$ • $\mathcal{D}_{H-Aço} = 0,3\times10^{-12}\ \frac{m^2}{s}$




$C_1 = 1,5\ Kmol/m^3$

$C_2 = 0\ Kmol/m^3$

## Solução

Lei de Fick ⇒ $N''_H = \mathcal{D}_{H_2-aço}\,\frac{\Delta C_H}{L} = 3\times10^{-13}\,\frac{m^2}{s}\times\frac{1,5\ Kmol}{2\times10^{-3}\ m^4}$

$N''_{H-aço} = 2,25\times10^{-10}\ Kmol/s\,m^2$

→ para transformar em $Kg/s\,m^2$, precisamos da massa molar do hidrogênio ⇒ $M_H = 2,02\ Kg/Kmol$

$n''_{H-aço} = M_H \times N''_{H-aço} \Rightarrow n''_{H-aço} = 2,02\ \frac{Kg}{Kmol}\times 2,25\times10^{-10}\ \frac{Kmol}{s\cdot m^2}$

$n''_{H-aço} = 4,545\times10^{-10}\ \frac{Kg}{s\,m^2}$ } $\dot{m}_H = n''_{H-aço}\times A$

→ área da superfície do tanque

$A = 4\pi r^2 = 4\pi\,(50\times10^{-3})^2\ m^2$

$A = 0,031416\ m^2 \Rightarrow \dot{m}_H = 1,4278\times10^{-10}\ \frac{kg}{s}$

## Queda de pressão

Gás perfeito → $\frac{P_1}{\rho_1} = R_H T_1 = \text{constante}$

$R_H = 8,31\ \frac{J}{mol\cdot K}\times\frac{1}{2,02\ \frac{g}{mol}} \Rightarrow R_H = 4,114\ \frac{kJ}{kg\cdot K}$

$\frac{P_1}{\rho_1} = 4,114\times(273+27) \Rightarrow \text{constante} = 1234,16\ \frac{kJ}{kg}$

Note que: $P = 1234,16\,\rho \Rightarrow \frac{dP}{dt} = 1234,16\,\frac{d\rho}{dt}$

e $\frac{d\rho}{dt} = V^{-1}\,\frac{dm}{dt} = \frac{\dot{m}_H}{V} \rightsquigarrow \frac{dP}{dt} = \frac{1234,16}{\frac{4}{3}\pi\left(50\times10^{-3}\right)^3}\,\dot{m}_H$

$$\frac{dP}{dt} = 2,357\times10^{6} \times 1,4278\times10^{-10}\ \frac{kJ}{kg\cdot m^3}\times\frac{kg}{s}$$

$$\frac{dP}{dt} = 3,3654\times10^{-4}\ \frac{kJ}{m^3\cdot s}$$ ⇝ Note que: $\frac{kJ}{m^3} = \underbrace{\frac{kN\cdot m}{m^3}}_{kPa}$

Logo: $\boxed{\frac{dP}{dt} = 0,33654\ \frac{Pa}{s}}$ ←

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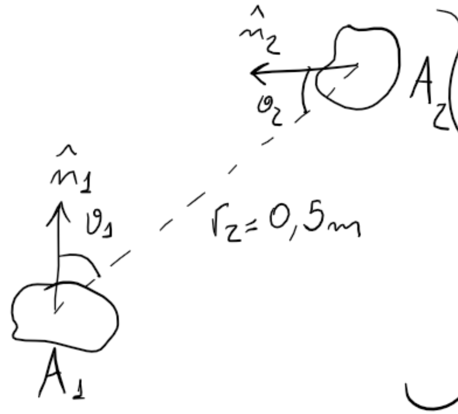
Questão 02

• Dados ⇒ $A_1 = 10^{-4}\,m^2$, $E_1 = 5\times10^{4}\,\frac{W}{m^2}$, Difusa

$\omega_{2-1} = ?$




$\theta_2 = 30°$

$\theta_1 = 60°$

$\omega_{2-1} = \frac{A_2\cos 30}{r_2^2}$

$$\omega_{2-1} = \frac{5\times10^{-4}\times\cos 30}{0,5^2} = 1,732\times10^{-3}\ sr$$

Se $E_1 = 5\times10^{4}\,\frac{W}{m^2}$ → difuso → $I_1 = \frac{E_1}{\pi}$

$I_1 = 1,5915\times10^{4}\,\frac{W}{m^2\cdot sr}$ } $q_{12} = A_1\cos 60°\, I_1\times\omega_{2-1}$

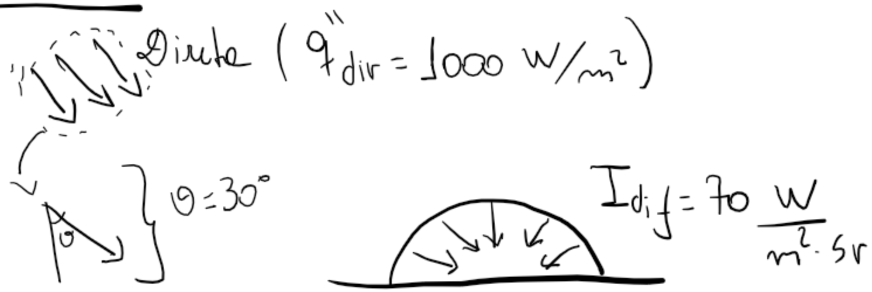
$$q_{12} = 10^{-4}\,m^2\cos 60°\times 1,5915\times10^{4}\,\frac{W}{m^2\cdot sr}\times 1,732\times10^{-3}\,sr$$

$\boxed{q_{12} = 1,004\times10^{-3}\,W}$ → (2)

$$G_2 = I_1 \times \omega_{2-1} = 1{,}5915 \times 10^{4} \frac{W}{m^2 \cdot sr} \times 1{,}732 \times 10^{-3}\ sr$$

$$\boxed{G_2 = 27{,}56\ W/m^2} \rightarrow (b)$$

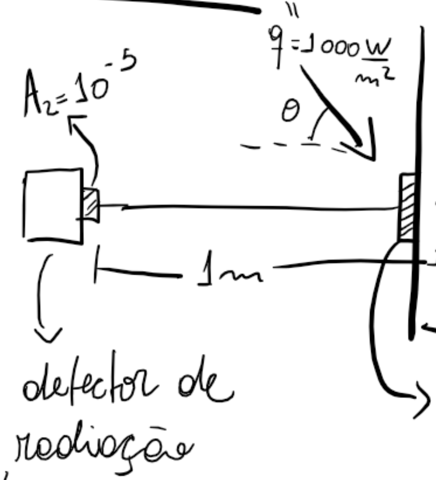
## Questão 03




$$G_{TOTAL} = \underbrace{1000 \frac{W}{m^2} \times \cos 30°}_{\text{parcela direta}} + \underbrace{\pi I_{dif}}_{\text{parcela difusa}}$$

$$G_{TOTAL} = 866{,}025 \frac{W}{m^2} + 219{,}91 \frac{W}{m^2} = \boxed{1085{,}93 \frac{W}{m^2}}$$

## Questão 04




θ = 30°

$0 \leq \lambda \leq 3\mu m \Rightarrow \varepsilon_{\lambda_1} = 0$

$3\mu m < \lambda \leq 10\mu m \Rightarrow \varepsilon_{\lambda_2} = 0{,}5$

$10\mu m \leq \lambda < \infty \Rightarrow \varepsilon_{\lambda_3} = 0{,}9$

Emissividade hemisférica total de $A_1$:

$$\varepsilon_1 = \varepsilon_{\lambda 1} \underbrace{\frac{\int_0^3 E_{\lambda,b}}{E_b}}_{F_{(0\to 3\mu m)}} + \varepsilon_{\lambda_2} \underbrace{\frac{\int_3^{10} E_{\lambda,b}}{E_b}}_{F_{(3\to 10\mu m)}} + \varepsilon_{\lambda_3} \underbrace{\frac{\int_{10}^{\infty} E_{\lambda,b}}{E_b}}_{F_{(10\to \infty\mu m)}}$$

$3 \times 700K = 2100\ (\lambda_1 T) \Rightarrow F_{(0\to 3\mu m)} = 0{,}0838$

$10 \times 700 = 7000\ (\lambda_2 T)$

$F_{(0\to 10\mu m)} = 0{,}808109$

$F_{(3\to 10\mu m)} = 0{,}8081 - 0{,}0838$

$F_{(3\to 10\mu m)} = 0{,}7243$

$F_{(10\to \infty\mu m)} = 1 - 0{,}8081$

$F_{(10\to \infty\mu m)} = 0{,}1919$

$\varepsilon_1 = 0 \times 0{,}0838 + 0{,}5 \times 0{,}7243 + 0{,}9 \times 0{,}1919 \Rightarrow \varepsilon_1 = 0{,}5348$

$E_1 = \underbrace{5{,}67 \times 10^{-8}}_{\sigma} \times \underbrace{700^4}_{T_1^4} \times \underbrace{0{,}5348}_{\varepsilon_1} \Rightarrow \boxed{E_1 = 7281{,}29 \, \frac{W}{m^2}}$

Além disso, temos que: $E_{1,r} = 1000 \, \frac{W}{m^2} \times \cos(30°)$

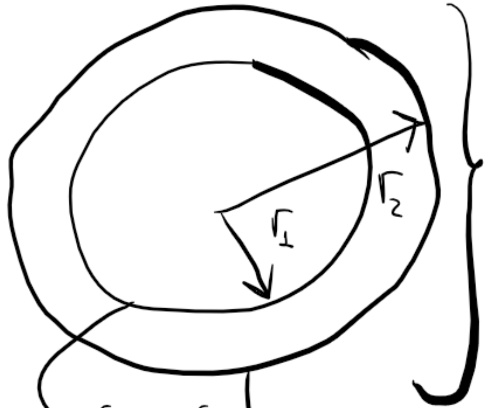
$E_{1,r} = 866{,}025 \, \frac{W}{m^2}$ ↳ energia refletida difusamente por 1

$I_1 = \frac{E_1 + E_{1,r}}{\pi} \rightsquigarrow \boxed{I_1 = 2593{,}37 \, \frac{W}{m^2 \cdot sr}}$

$\omega_{2-1} = \frac{10^{-5}}{1^2} \Rightarrow \omega_{21} = 10^{-5} \, sr$

$q_{12} = A_1 \times I_1 \times \omega_{21} \rightarrow \boxed{q_{12} = 2{,}5934 \times 10^{-6} \, W}$

# Questão 05




$r_1 = 0{,}4 \, m$

$r_2 = 0{,}6 \, m$

→ $\varepsilon = 0{,}05$, $T_1 = 95 \, K$

→ $\varepsilon = 0{,}05$, $T_2 = 280 \, K$

Eq. 13.26 (Incropera) $\Rightarrow q_{12} = \frac{\sigma A_1 (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1-\varepsilon_2}{\varepsilon_2}\left(\frac{r_1}{r_2}\right)^2}$

↳ para esferas concêntricas

$q_{12} = \frac{5{,}67 \times 10^{-8} \times 4\pi (0{,}4)^2 \times (95^4 - 280^4)}{\frac{1}{0{,}05} + \frac{0{,}95}{0{,}05}\left(\frac{0{,}4}{0{,}6}\right)^2} \Rightarrow q_{12} = \frac{-691{,}44}{28{,}44}$

$q_{12} = -24,31\ \frac{J}{s}$ ⇝ Se $\frac{dq}{dm} = 2,13\times10^{5}\ J/Kg$

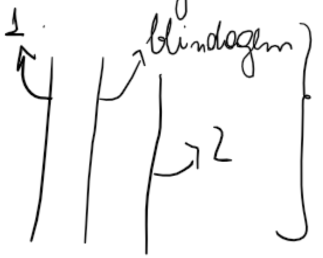
$\dot m = \frac{q_{12}}{\frac{dq}{dm}} = \frac{24,31}{2,13\times10^{5}}\ \frac{\cancel{J}}{s}\times\frac{Kg}{\cancel{J}}$ ⇝ $\dot m = 1,14\times10^{-4}\ \frac{Kg}{s}$

ou $\dot m = 0,114\ g/s$

## Questão 06

Sem blindagem, temos ⇒ $q_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{0,8}+\frac{1}{0,8}-1}$

Com blindagem, temos:




$q_{12}' = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{0,8}+\frac{1}{0,8}-\cancel{2}+2\times\left(\frac{1-\varepsilon_b}{\varepsilon_b}\right)+\cancel{2}}$

$\frac{q_{12}}{q_{12}'} = 10 = \frac{\frac{2}{0,8}+2\left(\frac{1-\varepsilon_b}{\varepsilon_b}\right)}{\frac{2}{0,8}-1}$

$\left(\frac{2}{0,8}-1\right)\times\frac{10}{2} = \frac{1}{0,8}+\frac{1-\varepsilon_b}{\varepsilon_b}$

$\frac{1-\varepsilon_b}{\varepsilon_b} = 6,25 \Rightarrow \varepsilon_b = \frac{1}{7,25}$

$\varepsilon_b = 0,138$