1) $\gamma = ?$ $\quad T = 37^\circ C$ $\quad M = 16 g/mol$

$V_s = ?$ $\quad P = 827{,}4\ kPa$

$\rho = ?$ $\quad R = 8{,}314\ J/K.mol$

Sol.: $\gamma = \rho g$ $\quad c/a$ $\quad \rho = \frac{1}{V_s}$

$$\boxed{\gamma = \frac{1}{V_s} \cdot g}$$

$V_s = \frac{V}{m}$ $\quad$ se for ideal: $PV = n.R.T$

$$PV = \frac{m}{M}.R.T$$

$$P\left(\frac{V}{m}\right)_{V_s} = \frac{RT}{M}$$

$$V_s = \frac{RT}{PM} = \frac{8{,}314 \cdot 310}{827400 \cdot 0{,}016}$$

$$\boxed{V_s = 0{,}195\ m^3/kg} \longrightarrow \gamma = \frac{9{,}81}{0{,}195}$$

$$\boxed{\gamma = 50{,}31\ N/m^3}$$

$\rho = \frac{1}{V_s}$

$\rho = \frac{1}{0{,}195} \longrightarrow \boxed{\rho = 5{,}128\ kg/m^3}$

2) $T = 32^\circ C$ $\quad R = ?$

$P = 206{,}85\ Pa$ $\quad \rho = ?$

$\frac{V}{P} = 0{,}073\ m^3/N$

Sol.: $\gamma = \frac{P}{V} = \frac{1}{0{,}073} = 13{,}69\ N/m^3$

$\gamma = \rho \cdot g$

$$\rho = \frac{\gamma}{g} = \frac{13,69}{9,81} \longrightarrow \rho = 1,396\ kg/m^3$$

$$\frac{\frac{kg}{m^3 \cdot s^2}}{m/s^2} = kg/m^3$$

Se não ideal: $PV = nRT$

$$PV = \frac{m}{M} \cdot R \cdot T = m \cdot \frac{R}{M} \cdot T$$

$$\frac{PV}{m} = R_G \cdot T$$

$$P \cdot V_s = R_G \cdot T \quad \text{ou} \quad P \cdot \frac{1}{\rho} = R_G \cdot T$$

$$R_G = \frac{P}{\rho \cdot T} = \frac{206850}{1,396 \cdot (32+273)} \left(\frac{\frac{kg}{m^2 \cdot s^2}}{\frac{kg}{m^3} \cdot K} \right) \quad \frac{kg\,m^2}{s^2} = J$$

$$R_G = 485,8\ J/kg.K$$

3) Volume inicial: V

Volume final: $0,97V$

$K = 2,22 \cdot 10^9\ Pa$

$$K = -V \cdot \frac{dP}{dV}$$

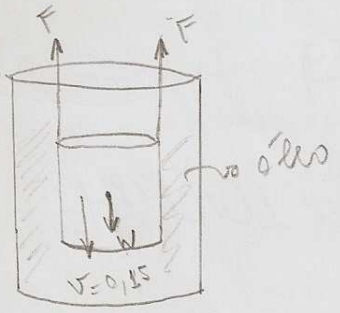
$$2,22 \cdot 10^9 = -V \cdot \frac{\Delta P}{(0,97V - V)}$$

$$2,22 \cdot 10^9 \cdot 0,03V = -V \cdot \Delta P$$

$$\Delta P = 6,66 \cdot 10^7\ Pa$$

4) cilindro de aço $\begin{cases} d = 2{,}5\ cm \\ L = 30\ cm \\ \gamma = 80000\ N/m^3 \end{cases}$

$v = 0{,}15\ m/s$



Sol: $F = \mu \cdot A \cdot \frac{v}{t}$

Como a velocidade constante:

$F_R = 0 \rightarrow F_V = Peso$

$Peso = m \cdot g$

$\mu \cdot A \frac{v}{t} = \gamma \cdot V$

$\frac{P}{V} = \frac{m}{V} \cdot g = \gamma$

$\mu \cdot 2\pi \cdot 1{,}25 \cdot 10^{-2} \cdot 0{,}3 \cdot \frac{0{,}15}{t} = 8 \cdot 10^3 \cdot \pi \cdot (1{,}25 \cdot 10^{-2})^2 \cdot 0{,}3$

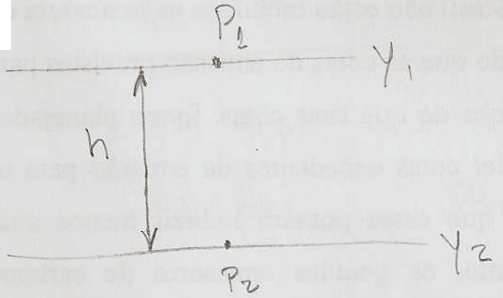
área: $2\pi r l$

volume: $\pi r^2 \cdot l$

$t = \frac{\mu \cdot 2 \cdot 0{,}15}{8 \cdot 10^3 \cdot 1{,}25 \cdot 10^{-2}}$

$\boxed{t = 0{,}003\ \mu}$

5)



$P_2 = P_1 + \rho g h$

Como: P_2 = manométrica

$P_1 = P_{atm} = 0$

a) querosene ($d = 0{,}94$)

d_o: $d_{que} = \frac{\rho_{que}}{\rho_{H_2O}} \rightarrow \rho_{que} = 0{,}94 \cdot 10^3\ kg/m^3$

$2P_{atm} - P_{atm} = 0{,}94 \cdot 10^3 \cdot 9{,}81 \cdot h$

$$h = \frac{101325}{0,94 \cdot 10^3 \cdot 9,81} \longrightarrow \boxed{h = 10,99 \text{ m de querosene}}$$

b) acetileno de tetrabromado ($d = 2,64$)

c/ o: $d_{acet} = \frac{\rho_{acet}}{\rho_{H_2O}} \longrightarrow \rho_{acet} = 2,64 \cdot 10^3 \text{ kg/m}^3$

$$2P_{atm} - P_{atm} = 2,64 \cdot 10^3 \cdot 9,81 \cdot h$$

$$h = \frac{101325}{2,64 \cdot 10^3 \cdot 9,81 \cdot h}$$

$\frac{kg}{m^3} \cdot \frac{m}{s^2}$

$\frac{kg}{m^3} \cdot \frac{m}{s^2}$

$$\boxed{h = 3,91 \text{ m}}$$

6) $P_{atm} = 705 \text{ mmHg}$

$P_{abs} = ?$

a) $P_{manom} = 83 \text{ psi}$

$P_{manom} = P_{abs} - P_{atm}$

$$\boxed{P_{abs} = P_{manom} + P_{atm}}$$

14,7 psi — 101325 Pa

83 psi — P_{manom}

$P_{abs} = 572\,107,14 + 101325$

$$\boxed{P_{abs} = 673,43 \text{ KPa}}$$

b) $P_{manom} = 6{,}435\ kgf/cm^2$

$6{,}435\ \frac{kgf}{cm^2}$ — P_{manom}

$1{,}0332\ \frac{kgf}{cm^2}$ — $101325\ Pa$

$P_{abs} = 631074{,}7 + 101325$

$\boxed{P_{abs} = 732{,}4\ kPa}$

7) área placa $= 0{,}5\ m^2$ $\quad t = 3\ mm$

$\mu_{óleo} = 10^{-2}\ N.s/m^2$ $\quad W = 60\ N$

$$\tau = \mu \cdot \frac{dv}{dt} \longrightarrow \frac{F}{A} = \mu \cdot \frac{dv}{dt}$$

c/ o : $F_R = 0 \rightarrow F = W$

$$F = \mu \cdot A \cdot \frac{dv}{dt}$$

$$60 = 10^{-2} \cdot 2 \cdot 0{,}5 \cdot \frac{v}{35 \cdot 10^{-4}} \longrightarrow \boxed{v = 21\ m/s}$$

$$N = \frac{N.s}{m^2} \cdot m^2 \cdot \frac{1}{m}$$

8)

$$d_{Hg} = \frac{\gamma_{Hg}}{\gamma_{H_2O}} \longrightarrow \gamma_{Hg} = 13,57 \cdot 9810$$

$$\gamma_{Hg} = 133121,7 \ N/m^3$$

$$P_A + \gamma_{H_2O} \cdot (x + h) - \gamma_{Hg} \cdot h + \gamma_{H_2O} \cdot y = P_B$$

$$276 \cdot 10^3 + 9810x + 9810h - 133121,7 \cdot h + 9810 \cdot y = 183 \cdot 10^3$$

$$x + y = 4,877 - 3,048$$

$$x = 1,829 - y$$

$$-93 \cdot 10^3 = 9810(1,829 - y) - 123291,27 \cdot h + 9810 \cdot y$$

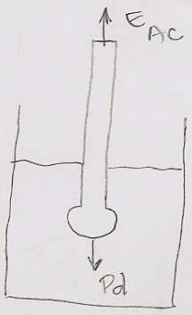
$$-93 \cdot 10^3 = 17942,49 - 123291,27 \cdot h$$

$$\boxed{h = 0,90 \ m}$$

9) $P = 0{,}7\ N$ $\quad d = ?$

(2,0) $h = 6\ cm$

Sol.: Em ácido ($d = 0{,}77$):

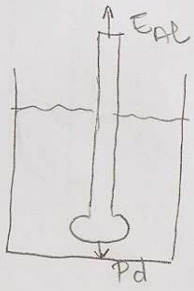


$$P_d = \gamma_{AC} \cdot V_{AC} \quad (0{,}25)$$

$$0{,}7 = 0{,}77 \cdot 9{,}81 \cdot 10^3 \cdot V_{AC}$$

$$V_{AC} = 0{,}093 \cdot 10^{-3}\ m^3 \quad (0{,}5)$$

Em Álcool ($d = 0{,}63$):



$$P_d = \gamma_{Al} \cdot V_{Al} \quad (0{,}25)$$

$$0{,}7 = 0{,}63 \cdot 9{,}81 \cdot 10^3 \cdot (V_{AC} + A.h) \quad (0{,}5)$$

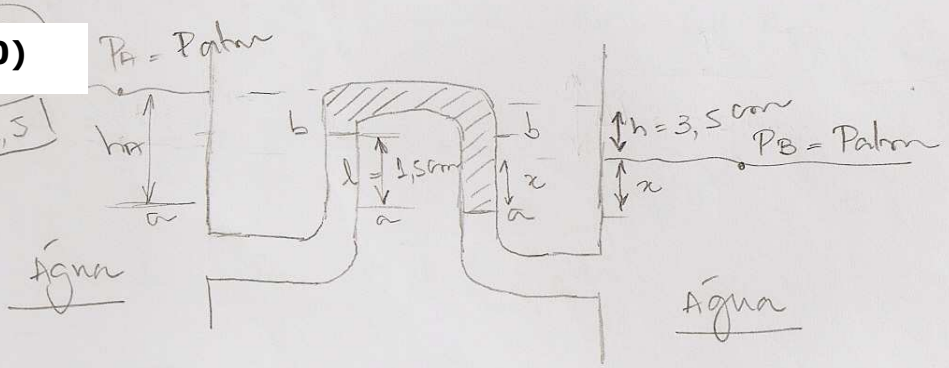
$$0{,}11 \cdot 10^{-3} = 0{,}093 \cdot 10^{-3} + \frac{\pi d^2}{4} \cdot 0{,}06$$

$$0{,}017 \cdot 10^{-3} = \frac{\pi \cdot d^2}{4} \cdot 0{,}06$$

$$d^2 = 3{,}609 \cdot 10^{-4} \quad (0{,}5)$$

$$\boxed{d = 0{,}019\ m = 1{,}9\ cm}$$

10) (1,5)



Sol:

braço esquerdo

$$\begin{cases} P_a = P_{atm} + \rho_{H_2O} \cdot g \cdot h_A \\ P_b = P_a - \rho_{H_2O} \cdot g \cdot l \end{cases} \quad (0{,}3)$$

$$\longrightarrow P_b = P_{atm} + \rho_{H_2O} \cdot g (h_A - l)$$

braço direito

$$\begin{cases} P_a = P_{atm} + \rho_{H_2O} \cdot g \cdot h_B \\ P_b = P_a - \rho_{óleo} \cdot g \cdot l \end{cases} \quad (0{,}3)$$

$$\longrightarrow P_b = P_{atm} + \rho_{H_2O} \cdot g \cdot (h_b - \text{doleo} \cdot l) \quad \left(\text{doleo} = \frac{\rho_{óleo}}{\rho_{H_2O}}\right)$$

(1.)

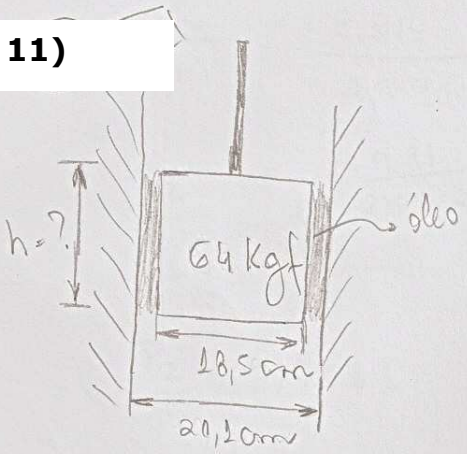
Então: $P_{atm} + \rho_{H_2O} \cdot g (h_A - \ell) = P_{atm} + \rho_{H_2O} \cdot g (h_B - d_{óleo} \cdot \ell)$ (0,3)

$h_A - h_B = \ell - d_{óleo} \cdot \ell = \ell (1 - d_{óleo})$

$\Delta h = \ell (1 - d_{óleo})$ (0,3)

$1 - d_{óleo} = \frac{3,5}{1,5} \longrightarrow$ **$d_{óleo} = 0,70$** (0,3)

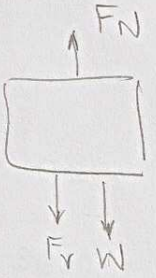
11)



$v = 2,5$ m/s
$F = 132$ kgf

$\mu = 3,2$ kgf.s/m²
$h = ?$

Sol.: cilindro subindo:



$v = cte \longrightarrow F_R = 0$

$F_N = F_v + W$

$132 = F_v + 64 \longrightarrow F_v = 68$ kgf (0,5)

$\tau = \frac{F_v}{A} = \mu \cdot \frac{v}{t} \longrightarrow F_v = \mu \cdot A \cdot \frac{v}{t}$

onde: $A = \pi \cdot d \cdot \ell$ (0,25)

$68 = 3,2 \cdot \pi \cdot 18,5 \cdot 10^{-2} \cdot h \cdot \frac{2,5}{\frac{(20,2 - 18,5) \cdot 10^{-2}}{2}}$ (0,25)

(1,0)

$h = \frac{36,58 \cdot 0,008}{2,5} \longrightarrow$ **$h = 0,1171$ m $= 11,71$ cm**

12) $H_1 = 3600\ m$ $\quad T = 15°C$

(2,0) $M_{AR} = 29\ g/mol$

a) $\% P = ?$ $\longrightarrow$ $h_2 = h_1 - 10\%\, h_1 = 3600 - 360 = 3240\ m$ (0,25)

$$P_2 = P_1 \cdot e^{\frac{-g}{R \cdot T} \cdot (y_2 - y_1)}$$

$$\bar{R} = \frac{R}{M} = \frac{8,314}{29 \cdot 10^{-3}} \longrightarrow \bar{R} = 286,7\ J/kg.K$$ (0,50)

$$\frac{P_2}{P_1} = e^{\frac{-9,81}{286,7 \cdot 288} \cdot (360)} = 0,9581$$

$$\frac{P_2}{P_1} = 0,9581 \quad \text{ou} \quad \boxed{4,18\%}$$ (0,50)

b) $\frac{\rho_2}{\rho_1} = ?$ $\longrightarrow$ $P_2 = 20\%\, h_1 + h_1$ (0,25)

$P_2 = 0,2 \cdot 3600 + 3600 = 4320\ m$

$\frac{\rho_2}{\rho_1} = \frac{P_2}{P_1} =$ cte e $\frac{P_2}{P_1} = e^{\frac{-g}{R \cdot T}(y_2 - y_1)}$

$$\frac{P_2}{P_1} = e^{\frac{-9,81}{286,7 \cdot 288} \cdot (720)} = 0,9180$$ (0,50)

13) $P_{manom} = -12\ kPa$

(2,5) $d_{óleo1} = 0,9 \qquad d_{óleo2} = 1,2 \qquad d_{Hg} = 13,6$

a) Braço A: $P_F = atm = 0 = P_E$

$d_{ar} \ll \rho_{liq} \longrightarrow P_{ar} = \text{desprezível} \longrightarrow P_M = P_D = -12\ kPa$

$\cancel{P_E}^{0} = P_D + \rho_{óleo1} \cdot g \cdot h$

$12 \cdot \cancel{10^3} = 0,9 \cdot 9,81 \cdot \cancel{10^3} \cdot Y \longrightarrow Y = 1,36\ m$ (0,25)

$h_F = 910 - 1,36 \longrightarrow \boxed{h_F = 908,64\ m}$ (0,25)

Braço B:

$P_H = P_D + \rho_{óleo1} \cdot g \cdot h \longrightarrow h = 910 - 907 = 3\ m$

$P_H = -12 \cdot 10^{+3} + 0,9 \cdot 10^3 \cdot 9,81 \cdot 3 \longrightarrow P_H = 14487\ Pa$ (0,25)

$P_H = \cancel{P_G}^{0} + \rho_{agua} \cdot g \cdot h_{G,H} \longrightarrow P_G = P_{atm} = 0$

$14487 = 10^3 \cdot 9,81 \longrightarrow h_{G-H} = 1,48\ m$ (0,25)

$h_G = 907 + 1,48 \longrightarrow \boxed{h_G = 908,48\ m}$ (0,25)

Braço C:

$P_J = P_H + \rho_{agua} \cdot g \cdot h \longrightarrow h = 907 - 905 = 2\ m$

$P_J = 14487 + 10^3 \cdot 9,81 \cdot 2$

$P_J = 34107\ Pa$ (0,25)

(3,)

$P_J = \cancel{P_I}^{0} + \rho_{oleo} \cdot g \cdot h_{I-J} \longrightarrow P_I = P_{atm} = 0$

$34107 = 1{,}2 \cdot 10^3 \cdot 9{,}81 \cdot h_{I-J} \longrightarrow h_{I-J} = 2{,}9\ m$ (0,25)

$h_I = 905 + 2{,}9 \Rightarrow \boxed{h_I = 907{,}9\ m}$

(0,25)

b) manômetro em U:

$P_K = P_J + \rho_{água} \cdot g \cdot h \longrightarrow h = 905 - 900 = 5\ m$

$P_K = 34107 + 10^3 \cdot 9{,}81 \cdot 5 \longrightarrow P_K = 83157\ Pa$

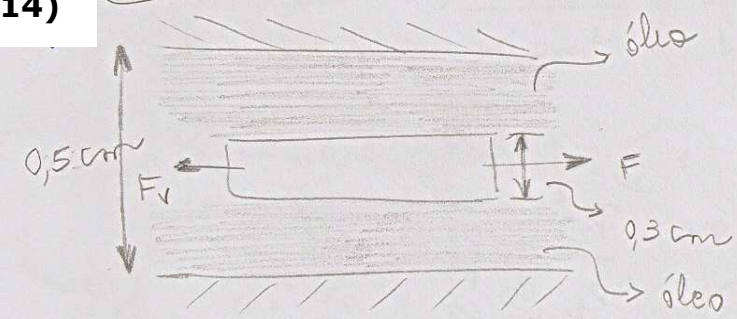
(0,25)

$P_K = \cancel{P_{atm}}^{0} + \rho_{Hg} \cdot g \cdot h_m$

$83157 = 13{,}6 \cdot 9{,}81 \cdot 10^3 \cdot h_m \longrightarrow \boxed{h_m = 0{,}62\ m}$

(0,25)

14) (1,0)



$A_{placa} = 100\ cm^2$

$\rho_{óleo} = 850\ kg/m^3$

$\nu_{óleo} = 7{,}625 \cdot 10^{-5}\ m^2/s$

$v = 0{,}15\ m/s$

Sol:

$$\sum F_R = 0 \quad (0{,}25)$$

$$F_V = F$$

onde: $\nu = \frac{\mu}{\rho} = \frac{kg/m \cdot s}{kg/m^3} = \frac{m^2}{s}$

$$F = \mu \cdot A \cdot \frac{dv}{dt} = \rho \cdot \nu \cdot A \cdot \frac{dv}{dt} = 850 \cdot 7{,}625 \cdot 10^{-5} \cdot 2 \cdot 100 \cdot 10^{-4} \cdot \frac{0{,}15}{0{,}2 \cdot 10^{-2}}$$

(0,25)

$$\boxed{F = 0{,}1094\ N} \quad (0{,}5)$$

15) (2,5)

nível do mar
1500 m de altitude } $T = 28°C = 301\ K$

Sol:

a) $\Delta y = (y_2 - y_1) = ?$

$P_2 = 97{,}5\% \cdot P_1$

$$P_2 = P_1 \cdot e^{-\frac{g_1}{R_1}(y_2 - y_1)} = P_1 \cdot e^{-\frac{g}{R \cdot T}\underbrace{(y_2 - y_1)}_{\Delta y}}$$

$$\ln 0{,}975 = -\frac{9{,}81}{\bar{R} \cdot 301} \cdot \Delta y$$

(0,25)

$$\bar{R} = \frac{R}{M} = \frac{8{,}314}{28{,}8 \cdot 10^{-3}} \rightsquigarrow \bar{R} = 288{,}68\ J/kg \cdot K$$

$$-0{,}025 = \frac{-9{,}81}{288{,}68 \cdot 301} \cdot \Delta y \longrightarrow \boxed{\Delta y = 224\ m} \quad (1{,}0)$$

(1.)

b) $\Delta y = ?$

$p_2 = 82\%\ p_1$

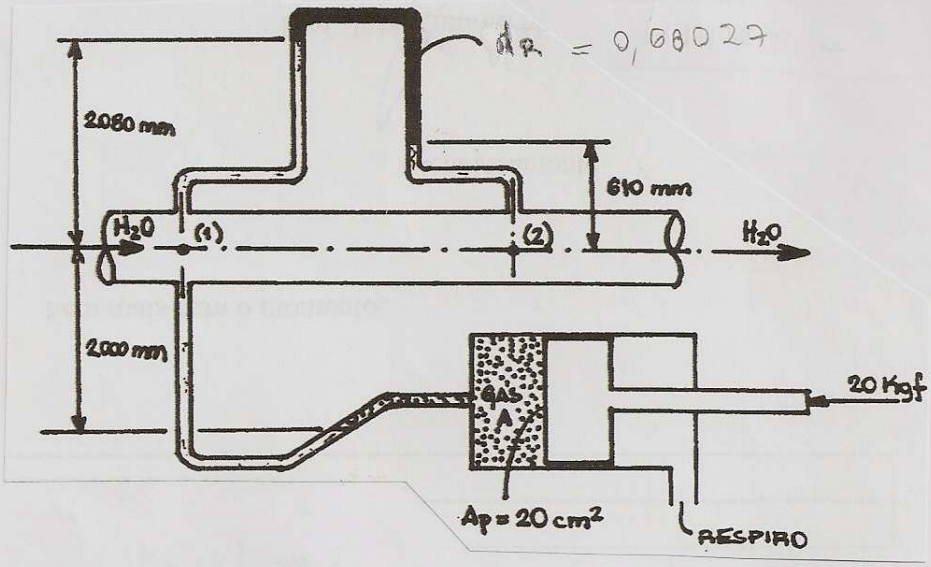
Sol: $\frac{p_2}{\rho_2} = \frac{p_1}{\rho_1} = cte$ ou $\frac{p_2}{p_1} = \frac{\rho_2}{\rho_1} = cte$ (0,25)

$$\ln \frac{p_2}{p_1} = -\frac{g}{\bar{R}.T}.\Delta y$$

$$\ln 0,82 = \frac{-9,81}{288,08.301}.\Delta y \longrightarrow \boxed{\Delta y = 2757,8\ m}$$ (1,0)

(3,5)

16)



Em (2): $P_{min} = 7.10^3\ Kgf/m^2$

a) $P_1 - P_2 = ?$

$$P_1 = P_2 - 0,61.\gamma_{H_2O} - 1,47.\gamma_R + 2,08.\gamma_{H_2O}$$

$$P_1 - P_2 = -0,61.10^3.9,81 - 1,47.0,68027.9810 + 2,08.9810$$

$$\left(\frac{Kg}{m^2}.\frac{m}{s^2}\right) = N/m^2$$

$\boxed{P_1 - P_2 = 4610,73\ Pa}$ (1,0)

b) $P_A = \frac{F}{A} = \frac{20\ kgf}{20\ cm^2} \cdot \frac{10^4\ cm^2}{1\ m^2} \cdot \frac{9,81\ N}{1\ kgf}$

$P_A = 98,1\ KPa$ (0,5)

c) $P_1 = P_A + 2 \cdot \gamma_{H_2O}$ onde: coluna de gás = desprezível

$P_1 = 98100 - 2 \cdot 9810$

$P_1 = 78,48\ KPa$ (1,0)

d) $P_1 - P_2 = 4610,73$

$P_2 = 78480 - 4610,73$

$P_2 = 73,87\ KPa$ (0,5)

e) Como em (2): $P_{min} = 7 \cdot 10^3\ kgf/m^2$

$P_{min} = 7 \cdot 10^3 \frac{kgf}{m^2} \cdot \frac{9,81\ N}{1\ kgf} \hookrightarrow P_{min} = 68,67\ KPa$

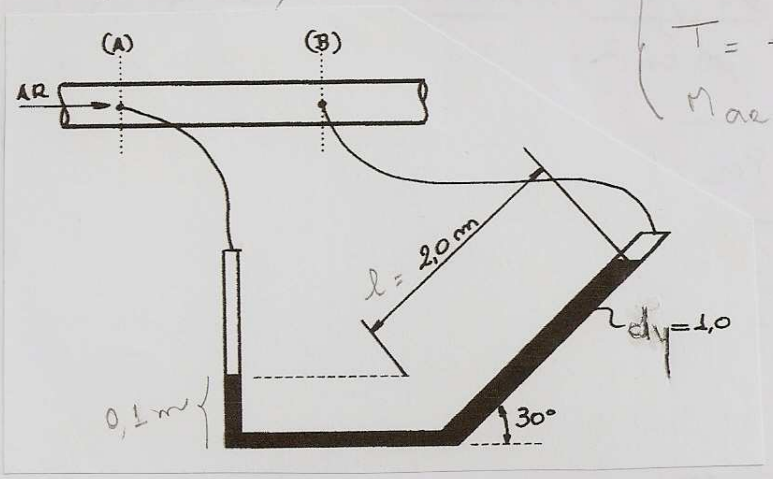
(0,5)

Como: $P_2 = 73,87\ KPa > P_{min} = 68,67\ KPa$

O dispositivo pode ser instalado!

17) (3,0)

Instalações a 3600 m { $P_{atm} = 57,8$ KPa; $T = -55°C$; $M_{ar} = 28,8$ g/mol



a) $P_A - P_B = 8,80$ KPa

onde: $\operatorname{sen} 30° = \frac{h}{l}$

$P_A = P_B + 2 \cdot \operatorname{sen} 30° \cdot \gamma_y - 0,1 \cdot \gamma_y$ (0,25)

$P_A - P_B = 2 \cdot 0,5 \cdot 1 \cdot 9810 - 0,1 \cdot 9810 \cdot 1$

$P_A - P_B = 8829$ Pa (c.g.c) (1,0)

b) Nas grandes variações da diferença de pressão, ela independe da altura onde o dispositivo é instalado. (0,5)

c) P_{atm} em 13200 m = ?

$P_2 = P_1 \cdot e^{-\frac{g}{R \cdot T}(y_2 - y_1)}$

$P_2 = 57800 \cdot e^{-\frac{9,81}{288,8 \cdot 218} \cdot (13200 - 3600)}$ (1,0)

$P_2 = 57800 \cdot e^{-1,49584} = 67000 \cdot 0,224059$

$P_2 = 12950,62$ N/m²

P_2 — 101325 Pa — 760 mmHg

$P_2 = 97,14$ mmHg (0,25)