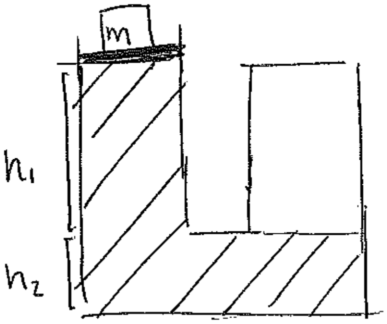
Physics 207 Week 13a, problem 2



$m = 6\,kg$ $\quad T = 27°C$

$\rho_w = 1000\ kg/m^3$ $\quad h_1 = 10m$

$A = 0.0004 m^2$ $\quad h_2 = 5m$

$P_{atm} = 1E5\ N/m^2$ $\quad k_B =$

~~P_0~~

a) <u>Bernoulli's</u> <u>Eqn.</u>

$$P_0 + \rho g h_0 + \tfrac{1}{2}\rho v_0^2 = P + \rho g h + \tfrac{1}{2}\rho v^2$$

since the liquid isn't flowing, $v_0 = v = 0$, which gives

$$P_0 + \rho g h_0 = P + \rho g h$$

$$\Longrightarrow P(h) = P_0 + \rho g (h_1 - h)$$

Now we have to find P_1. This will be equal to air pressure, P_{atm}, plus the pressure due to the 6kg mass, ie:

$$P_0 = P_{atm} + \frac{(6.0kg)(10m/s^2)}{0.0004m^2} = 2.5E5\ N/m^2$$

$$\Longrightarrow P(h) = 2.5E5\ N/m^2 + \rho g (h_0 - h)$$

$$\Longrightarrow P(0) = 2.5E5\ N/m^2 + (1000\ kg/m^3)(10\ m/s^2)(15m)$$

$$= \boxed{4E5\ N/m^2}$$

b) We can't use the ideal gas law because we don't have enough info, but we know the pressure at the gas-water interface is equal. Thus:

$$P_{gas} = P(5) = 2.5E5\ N/m^2 + (1000\ kg/m^3)(10\ m/s^2)(15m-5m)$$

$$= 3.5E5\ N/m^2$$

c) Now, we can use the ideal gas law! ∇ Remember to use Kelvin!! ∇

$$PV = N k_B T$$

$$\Longrightarrow N = \frac{PV}{k_B T}$$

$$= \frac{P h_1 A}{k_B T}$$

$$= \frac{(3.5E5\ N/m^2)(10m)(0.0064m^2)}{(1.381E-23\ \frac{m^2 kg}{sK})(300K)}$$

$$\boxed{= 3.38E23}$$

OR

$$PV = nRT$$

$$\Longrightarrow n = \frac{PV}{RT}$$

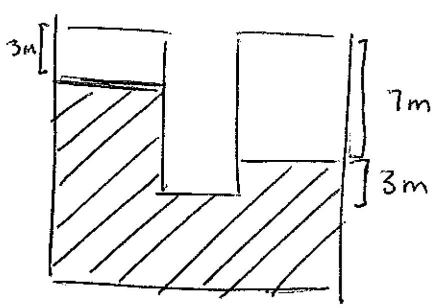
$$= \frac{(3.5E5\ N/m^2)(10m)(0.0064m^2)}{(8.314\ \frac{kg \cdot m^2}{s^2 K\, mol})(300K)}$$

$$n = 0.561\ mol$$

$$\Longrightarrow N = 0.56\ mol \cdot \frac{6.02E23}{mol}$$

$$\boxed{N = 3.38E23}$$

d)



Since the water is incompressible, the gas must now occupy less space. Since the temp is the same, we can use:

$$P_i V_i = P_f V_f$$

$$\Longrightarrow P_f = P_i \left(\frac{V_i}{V_f}\right)$$

$$= P_i \left(\frac{A h_1}{A(h_1 - 3m)}\right)$$

$$= (3.5E5\ N/m^2)\left(\frac{10m}{7m}\right)$$

$$\boxed{= 5E5\ N/m^2}$$