PHY1321 PHY1331 Fall 2020 Assignment 1. Due Sept 25, 7:00PM

LAST NAME (TYPED): ___________________

SOLUTIONS

1 Since $P_0 = \rho g h$ $\qquad h = \frac{P_0}{\rho g} = \frac{1.013\times10^5 Pa}{(1130kg/m^3)(9.81kg/ms2} = 9.13m$

2 Let h be the height of the water column added to the right side of the U–tube. Then when equilibrium is reached, the situation is as shown in the sketch at right. Now consider two points, A and B shown in the sketch, at the level of the water–mercury interface. By Pascal's Principle, the absolute pressure at B is the same as that at A.

But, $P_A = P_0 + \rho_w g h + \rho_{\mathrm{Hg}} g h_2$ and
$P_B = P_0 + \rho_w g\left(h_1 + h + h_2\right)$.

Thus, from $P_A = P_B$, $\rho_w h_1 + \rho_w h + \rho_w h_2 = \rho_w h + \rho_{\mathrm{Hg}} h_2$, or

$$h_1 = \left(\frac{\rho_{Hg}}{\rho_{water}} - 1\right) h_2 = (13.61)(0.8cm) = 10.08cm$$

3

a) $\qquad pV = nRT \Rightarrow (101000)V = (1)(8.31)(273) = 0.0224m^3 = 22.4l$

b) $\qquad pV = nRT \Rightarrow pV = \frac{m}{M}RT \Rightarrow \frac{pM}{RT} = \frac{m}{V} \Rightarrow \rho = \frac{pM}{RT}$

c) $\qquad \rho = \frac{pM}{RT} = \frac{(101300)(0.032)}{(8.31)(293)} = 1.331\frac{kg}{m^3}$

4 There are 2.5moles of molecular oxygen gas in the first section, so

$$P_i V_i = nRT \Rightarrow P_i(O_2) = \frac{2.5\cdot 8.31\cdot 383}{0.1}Pa = Pa = 79568Pa$$

There are 20 moles of molecular hydrogen gas in the first section, so

$$P_i V_i = nRT \Rightarrow P_i(H_2) = \frac{20\cdot 8.31\cdot 383}{0.1}Pa = 636546Pa = 636kPa$$

B) after the reaction there will be 5 moles of steam and 15moles of molecular hydrogen in a 200 liter container. The final pressure will be a sum of the partial pressures taken independently

$$\boldsymbol{P_f V_f = nRT \Rightarrow P_f(H_2O) = \frac{(5)\,(8.31)\,(383)}{0.2}Pa = 79568Pa = 79.6kPa}$$

$$\boldsymbol{P_f V_f = nRT \Rightarrow P_f(H_2) = \frac{(15)\,(8.31)\,(383)}{0.2}Pa = 238705 = 239kPa}$$

5

$$\Delta S = \gamma S \Delta T = 2\alpha S \Delta T = 2(4.86\cdot 10^{-6})\cdot(4)\cdot(-220)cm^2 = -0.0085536cm^2$$

$$S_f = S_i + \Delta S = 3.991446cm^2$$

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$$N_f = \frac{S_f}{S_i} N = \frac{3.991446}{4} 5432 = 5420.38 = 5420 \; full \; stars$$

6 $pV = nRT \; so \; pV = RT\frac{N}{N_A} \; and \; thus \; p = RT\frac{N}{VN_A} = \frac{N}{V}\frac{RT}{N_A} = \frac{10^6}{m^3}\frac{(8.314)(3)Pa\,m^3}{6.02 \cdot 10^{23}} = 4.14 \cdot 10^{-17} Pa$

7 21.0°C. $pV = RTn = RT\frac{N}{N_A}$ and so N= $\frac{pVN_A}{RT} = \frac{(10^{-10}Pa)(10^{-6}m^3)(6.02 \cdot 10^{23})}{(8.314)(294)\,Pa\,m^3} = 24629$

8 *The number of collisions will equal the number of atoms inside the cylinder of base of radius 500m and the height of 3 10^7m(0.1c)(1s). Given the interstellar number density of 1 atom per cm^3 we get 2.356 $\cdot 10^{19}$ of atoms, and the same number of collisions.*

9 Lets h_i be initial height of the air column in the bell, h_f the final height of the air column in the bell when it is submerged. $V_i = Ah_i$; $V_f = Ah_f$

(NOTE :
A has not been given (cross-section area of the bell)_ but it might be not needed to solve this problem

Using the ideal gas equation $pV = nRT$ we can write the following:

$p_i A h_i = nRT_i$; $p_f A h_f = nRT_f$; since n stays constant as the bell is sealed by water, we have :

$$\frac{p_i A h_i}{RT_i} = n = \frac{p_f A h_f}{RT_f} \Rightarrow \frac{p_i h_i}{T_i} = \frac{p_f h_f}{T_f}$$; where $p_f = 101300 + h_x \rho g$ and $h_x = 90m - (2.7 - h_f)$

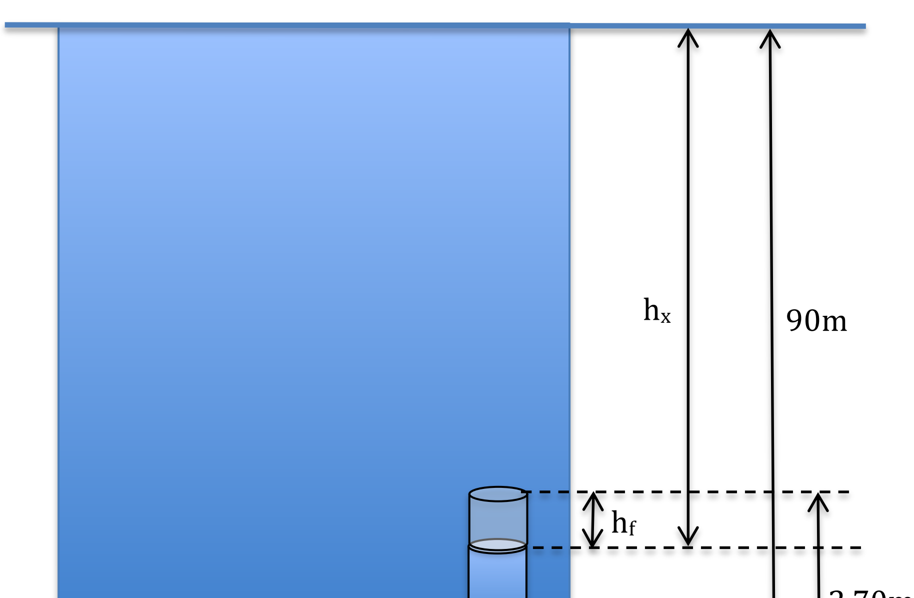
$\Rightarrow$;

$$h_f = \frac{T_f}{T_i}\frac{p_i}{p_f}h_i = \frac{277}{298}\frac{101300}{101300 + (90 - 2.70 + h_f)(9.8)(1033)} 2.70m$$

Solving resulting quadratic equation gives the answer to be h_f =0.25m

The height of the air column at the top of the bell is 0.25m, so the water level in the bell will reach 2.45m.

(b) the additional pressure needed to push the water from the bell
(pressure exerted by 2.45m column) is 24,802Pa, so the total pressure needed is 1012406Pa.
(atmospheric pressure plus pressure of 90 m water column)



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10 *8* *The heat necessary to heat up the water is* $Q = mc\Delta T = (1000)(4186)(60 - 15) = 188370000J$

The Power delivered by the sunlight P=550 12 =6600W. this means 6600 J of energy every second,
It will take 7.92hours to heat up this amount of water. (7 hrs. 56min.)

11 $P = \sigma AeT^4 = (5.67 \cdot 10^{-8})(4\pi \left(9 \cdot 10^8\right)^2 5800^4 W = 6.53 \cdot 10^{26} W$

12 ***ANSWER:***
We treat the earth below is an insulator. The square meter must radiate in the infrared as much energy as it absorbs, . Assuming that for blackbody blacktop: $P=\sigma AT4$ *so that* $1200W=5.67\ 10{-8}WK4m2(1m2)T4$
T=384K (Yes! You can cook an egg on it.)

13 SOLUTION:

Unknown amount of water was cooled down from 20°C to 16 °C. It took Q_h of heat.

$$Q_h = m_{water}c_{water}(T_f - T_{i1}) = (m_{water})\left(4186\frac{J}{kg\ {}^oC}\right)(16 - 20\ {}^oC) = -16744m_{water}$$

The 5 kg of ice had to go through three processes to reach the 16°C (as melted water)
It had to be warmed up as ice from -10°C to 0°C, had to be melted and the melted water had to be heated to 16°C. All of this required the total heat Q_c given by:

$$Q_c = +m_{ice}c_{ice}(0 - (-10)) + m_{ice}L + m_{ice}c_{water}(16 - 0)$$

$$Q_c = (5)(2050)(10)\mathrm{J} + (334000)(5)\mathrm{J} + (5)(4186)(16)J = 2107380J$$

Since $Q_c + Q_h = 0$ $\quad 2107380J - 16744m_{water} = 0\ and\ m_{water} = 125.9kg$

ANS: Initially there was 126kg of water at 20°C and 5 kg of ice at -10°C

14 A 1kg of ice at -10° C is added to 3 kg of steam at 130°C. Answer the following questions:

a) What is the phase of the system of ice + steam, if no heat escaped from it?
b) What is the final temperature when the equilibrium is established ?
(Use the opposite side of this page to provide details of the solution. Present the summary in the space below.)

CHECK THE PROBLEM SOLVING VIDEO FOR THE DISCUSSION OF THIS TYPE OF PROBLEM

L_1=334000 J/kg (latent heat of fusion) L_2=2260000J/kg (latent heat of evaporation)

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c_{ice}=2108 J/(kg K); c_{steam}=1996 J/(kg K); c_{water}=4186 J/(kg K)

a) It takes 793200J to i) warm up the ice to 0°C, ii) melt it, iii) warm up the water to 100°C.

$Q_{ice} = Q_{ice1} + Q_{ice2} + Q_{ice3} = m_1 c_{ice}(10) + m_1 L + m_1 c_{water}(100)$

Q_{ice} = (2108)(10)+334000+(4186)(100) = 773680(J)

II) When the steam cools off to 100°C and converts to the liquid water it can give off 6959640J of heat.

$Q_{steam} = Q_{steam1} + Q_{steam2} = m_2 c_{steam}(30) + m_2 L_2 = 179640$ +6780000 = 6959640(J)

Since 6.9MJ>0.77MJ, the 1 kg water from the ice will be brought to 100C, before the whole steam will be converted to water. The final temperature (in equilibrium) will be 100°C.

b) Thus only part of the steam will convert to liquid water: $Q_{steam} - Q_{ice} = m_{steam\ left} L_2$

In the equilibrium state there will be 2.74kg of steam and 1.26kg of water at 100°C