

STUDENT #: 300018159

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ASSIGNMENT 1:

Pressure, Temperature, Ideal Gas Equation.

Released: Sept 15

Due: Sept 22 6PM

Each question is marked out of 4 points, In addition to this there are 4 points for presentation/aesthetics.

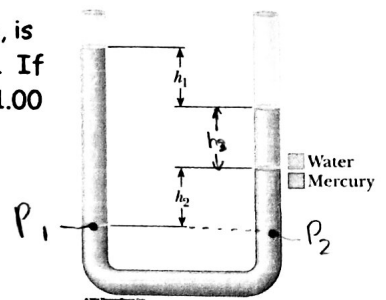
- 1 HS teacher duplicated Torricelli's barometer using a mineral oil, of density 1730 kg/m^3 , as the working liquid. What was the height h of the oil column for normal atmospheric pressure?

$$P_{\text{atm}} = \rho g h$$

$$101300 \frac{\text{N}}{\text{m}^2} = (1730 \frac{\text{kg}}{\text{m}^3}) \left(\frac{9.81 \text{ m}}{\text{s}^2} \right) (h)$$

$h = 5.9689 \text{ meters}$

- 2 A U-tube of uniform cross-sectional area, open to the atmosphere, is partially filled with mercury. Water is then poured into both arms. If the equilibrium configuration of the tube is as shown in, with $h_2 = 1.00 \text{ cm}$, determine the value of h_1 .



$\rho_{\text{H}_2\text{O}} = 1 \frac{\text{g}}{\text{cm}^3}$ $\rho_{\text{Hg}} = 13.56 \frac{\text{g}}{\text{cm}^3}$

$$\rho_{\text{H}_2\text{O}} g (h_1 + h_2 + h_3) = \rho_{\text{Hg}} g h_2 + \rho_{\text{H}_2\text{O}} g h_3$$

$$\rho_{\text{H}_2\text{O}} g h_1 + \rho_{\text{H}_2\text{O}} g h_2 + \rho_{\text{H}_2\text{O}} g h_3 = \rho_{\text{Hg}} g h_2 + \rho_{\text{H}_2\text{O}} g h_3$$

$$\rho_{\text{H}_2\text{O}} g h_1 + \rho_{\text{H}_2\text{O}} g h_2 = \rho_{\text{Hg}} g h_2 \quad \rightarrow \quad (1 \frac{\text{g}}{\text{cm}^3}) (h_1) + (1 \frac{\text{g}}{\text{cm}^3}) (1 \text{ cm}) = (13.56 \frac{\text{g}}{\text{cm}^3}) (1 \text{ cm})$$

$$\rho_{\text{H}_2\text{O}} h_1 + \rho_{\text{H}_2\text{O}} h_2 = \rho_{\text{Hg}} h_2$$

$h_1 = 12.569 \text{ cm}$

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- 3 a) Show that 1 mole of any gas at atmospheric pressure and at 0°C is taking 22.4 liters of volume
 (b) Show that the density of an ideal gas occupying a volume V is given by PM/RT , where M is the molar mass.
 (c) Determine the density of oxygen gas at atmospheric pressure and 20.0°C .

a) $PV = nRT$

$$(1 \text{ atm})V = 1 \text{ mol} \left(\frac{0.08206 \cdot \text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (273.4^\circ \text{K})$$

$$(1 \text{ atm})V = \left(\frac{22.49 \text{ mol} \cdot \text{atm} \cdot \text{K} \cdot \text{L}}{\text{mol} \cdot \text{K}} \right)$$

$$V = \frac{22.49 \text{ atm} \cdot \text{L}}{\text{atm}}$$

$V = 22.4 \text{ L}$

b) $PV = nRT$

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

$$PM = \frac{mRT}{V}$$

$$\frac{PM}{RT} = \frac{m}{V}$$

$D = \frac{PM}{RT}$

$n = \frac{m}{M}$

$D = \frac{m}{V}$

Part "c" on back side of paper

$$\begin{aligned}
 T_{(K)} &= T_{(^\circ\text{C})} + 273.15 \\
 T_{(K)} &= 20 + 273.15 \\
 T_{(K)} &= 293.15 \text{ K}
 \end{aligned}$$

$$\begin{aligned}
 M_{\text{O}_2} &= (15.99 \frac{\text{g}}{\text{mol}} + 15.99 \frac{\text{g}}{\text{mol}}) \\
 &= 31.99 \frac{\text{g}}{\text{mol}}
 \end{aligned}$$

$$D = \frac{PM}{RT} = \frac{(1 \text{ atm}) (31.998 \frac{\text{g}}{\text{mol}})}{\left(\frac{0.082057 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right) (293.15 \text{ K})}$$

$$= \frac{(1 \text{ atm}) (31.998 \frac{\text{g}}{\text{mol}})}{24.055 \text{ L} \cdot \text{atm} \cdot \cancel{\text{K}} \cdot \cancel{\text{mol}} \cdot \cancel{\text{K}}}$$

$$= \frac{31.998 \text{ g}}{\cancel{\text{mol}} \cdot \cancel{\text{mol}}} \times \frac{\cancel{\text{mol}}}{24.055 \text{ L}}$$

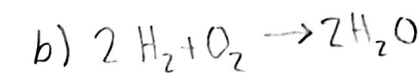
$$= \frac{31.998 \text{ g}}{24.055 \text{ L}} = 1.33 \frac{\text{g}}{\text{L}}$$

ASSIGNMENT 1: CONT

- 4 160 grams of oxygen and 40 grams hydrogen gas occupy separate, equal sections of 200 liter tank. The divide is removed and the gases are allowed to mix and react with each other. The temperature is kept constant at 130 °C, throughout the process
- a) find the pressure of each gas in the separate containers
b) find the pressure after the reaction ends.

$$a) n_{O_2} = \frac{160g}{31.998 g/mol} = 5 \text{ mol}$$

$$n_{H_2} = \frac{40g}{2.016 g/mol} = 19.84$$



$$\rightarrow \frac{2}{1} \text{ mols } O_2 = \text{ mols } H_2?$$

10 mols $O_2 \neq 19.84$ mols $H_2 \rightarrow O_2$ limiting reagent.

$$(5 \text{ mol } O_2) \times \left(\frac{2 H_2O}{1 \text{ mol } O_2} \right) = 10 \text{ mol } H_2O(g)$$

$$19.84 \text{ mol } H_2 - 10 \text{ mol } H_2 = 9.84 \text{ mol } H_2(g)$$

$$P_{total} = P_{H_2} + P_{H_2O}$$

$$P_{H_2} = \frac{(9.84 \text{ mol}) \left(\frac{0.082057 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (403.15 \text{ K})}{200 \text{ L}} = 1.628 \text{ atm}$$

$$P_{H_2O} = \frac{(10 \text{ mol}) \left(\frac{0.082057 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (403.15 \text{ K})}{200} = 1.654 \text{ atm}$$

$$P_{tank} = P_{H_2} + P_{H_2O} = 3.282 \text{ atm}$$

$$P_{O_2} = \frac{(5 \text{ mol}) \left(\frac{0.082057 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (403.15 \text{ K})}{100 \text{ L}}$$

$$= 1.654 \text{ atm}$$

$$P_{H_2} = \frac{(19.84 \text{ mol}) \left(\frac{0.082057 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (403.15 \text{ K})}{100 \text{ L}}$$

$$= 6.563 \text{ atm}$$

- 5 A telescope forms an image of part of a cluster of stars on a square silicon charge-coupled detector (CCD) chip 2.00 cm on each side. A star field is focused on the CCD when it is first turned on and its temperature is 27.0°C. The star field contains 5432 stars scattered uniformly. To make the detector more sensitive, it is cooled to -173°C. How many star images then fit onto the chip? The average coefficient of linear expansion of silicon is $4.68 \times 10^{-6} (\text{°C})^{-1}$.

$$\frac{\Delta L}{L_1} = \alpha_L \Delta T$$

$$L_2 = 2 - 1.872 \times 10^{-3} = 1.998 \text{ cm}$$

$$\frac{\Delta L}{2.00 \text{ cm}} = \left(\frac{4.68 \times 10^{-6}}{\text{°C}} \right) (-173 \text{°C} - 27 \text{°C})$$

$$\frac{2.00 \text{ cm}}{1.998 \text{ cm}} = \frac{1000}{999}$$

$$\Delta L = \left(\frac{(4.68 \times 10^{-6}) \times (-200 \text{°C})}{\text{°C}} \right) (2.00 \text{ cm})$$

$$5432 \left(\frac{1000}{999} \right) = 5437.4$$

$$\Delta L = -1.872 \times 10^{-3}$$

∴ 5437.4 stars will now fit fit onto the chip