AP CHEMISTRY

TOPIC 3: GASES, PRACTICE FOR QUIZ

Day 41:

- Dalton's Law of Partial Pressures
- Gas collection over Water
- Real Gases
- Gas Density
- Gas Molar Mass
- Kinetic Molecular Theory of Gases
- Effusion and Diffusion

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1) Calculate the density of manganese(III) sulfide vapor at 3025 torr and at a temperature of 1275 ^{0}C?

$$\boldsymbol{PV = nRT}$$

$$PV = \frac{m}{M}RT$$

$$P = \frac{m}{VM}RT$$

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

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

manganese(III) sulfide

$$\boldsymbol{Mn_2S_3 = (2)(54.94\ g\ mol^{-1}) + (3)(36.06\ g\ mol^{-1}) = 206.06\ g\ mol^{-1}}$$

$$\boldsymbol{1275 + 273 = 1548\ K}$$

$$\frac{3025\ torr}{} \times \frac{1\ atm}{760\ torr} = 3.98\ atm$$

$$\frac{m}{V} = \frac{PM}{RT} = \frac{(3.98\ atm)(mol \cdot K)(206.06\ g)}{(0.0821\ atm \cdot L)(1548\ K)(mol)} = 6.45\ g\ L^{-1}$$

2) Calculate the root mean square velocity for the xenon atoms in a sample of xenon gas at –144.68 ^{0}C.

$$Xe = \frac{131.29\ g}{mol} \times \frac{1\ kg}{1000\ g} = 0.13129\ kg\ mol^{-1}$$

$$u_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{(3)(8.31\ kg \cdot m^2)(128.32\ K)\left(mol\right)}{\left(mol \cdot K \cdot \sec^2\right)\left(0.13129\ kg\right)}}$$

$$u_{rms} = \sqrt{\frac{24366.04159\ m^2}{\sec^2}} = 156\ m\ \sec^{-1}$$

3) How many times faster would phosphorus penta-oxide gas diffuse than sulfur hexa-bromide gas?

$$\boldsymbol{PO_5 = 110.974\ g\ mol^{-1}}$$

$$\boldsymbol{SBr_6 = 511.46\ g\ mol^{-1}}$$

$$\frac{rate_{PO_5}}{rate_{SBr_6}} = \sqrt{\frac{M_{SBr_6}}{M_{PO_5}}} = \sqrt{\frac{511.46}{110.974}} = 2.15$$

PO_5 diffuses 2.15 times faster than SBr_6

OR

$$\frac{rate_{SBr_6}}{rate_{PO_5}} = \sqrt{\frac{M_{PO_5}}{M_{SBr_6}}} = \sqrt{\frac{110.974}{511.46}} = 0.465$$

SBr_6 diffuses 0.465 times faster than PO_5

Translation, SBr_6 is SLOWER (since the value is less than one)

4) Gas “X” diffuses one-sixth as fast as gas “Y”. Gas “Y” has a molecular mass = 18.572 g mol^{-1}. Calculate the molar mass of gas “X” and identify the gas as either, CO_2, $Pb_3(PO_4)_4$, Sn, $Os_2(SO_4)_3$, or O_2

$$\frac{rate_X}{rate_Y} = \frac{1}{6} = \sqrt{\frac{M_Y}{M_X}} = \sqrt{\frac{18.572}{M_X}}$$

Therefore.

$$\left(\frac{1}{6} = \sqrt{\frac{18.572}{M_X}}\right)^2 = \frac{1}{36} = \frac{18.572}{M_X}$$

$$M_X = \frac{(36)(18.572)}{1} = 668.58 \;\; g \;\; mol^{-1}$$

$$668.58 \;\; g \;\; mol^{-1} = Os_2\left(SO_4\right)_3$$

5) Propane gas, C_3H_8 , is collected over water at 30.0 ^{0}C. The atmospheric pressure on that day was recorded at 0.986 atm. of pressure. Calculate the volume of propane gas that must be collected to obtain 7.55 grams of propane gas? (At 30.0 ^{0}C the vapor pressure of water is 31.824 torr.)

$$P_T = P_{C_3H_8} + P_{H_2O} = 0.986\ atm \quad ; \quad P_{H_2O} = 31.824\ torr$$

$$P_T = \frac{0.986\ atm}{} \times \frac{760\ torr}{1\ atm} = 749.36\ torr \quad ; \quad P_{C_3H_8} = P_T - P_{H_2O}$$

$$P_{C_3H_8} = 749.36\ torr - 31.824\ torr \quad ; \quad P_{C_3H_8} = 717.536\ torr$$

$$n_{C_3H_8} = \frac{7.55\ g\ C_3H_8}{} \times \frac{1\ mol\ C_3H_8}{44.0962\ g} = 0.1712\ mol\ C_3H_8$$

$$P_{C_3H_8} = \frac{717.536\ torr}{} \times \frac{1\ atm}{760\ torr} = 0.9441\ atm$$

$$V = \frac{nRT}{P} = \frac{(0.1712\ mol)(0.0821\ atm \cdot L)(303\ K)}{(0.9441\ atm)(mol \cdot K)} = 4.51\ L$$

6) A sample of inert gases mixed together with a pressure of 2580 torr contains 25.0 % nitrogen gas and 75.0 % radon gas by mass. What are the partial pressures of the individual gases?

Let's do it the EASY way… and consider these two gases to equal 100 grams (total mass)

$$n_{N_2} = \frac{25.0\ g\ N_2}{} \times \frac{1\ mol\ N_2}{28.014\ g} = 0.8924\ mol\ N_2$$

$$n_{Rn} = \frac{75.0\ g\ Rn}{} \times \frac{1\ mol\ Rn}{222\ g} = 0.3378\ mol\ Rn$$

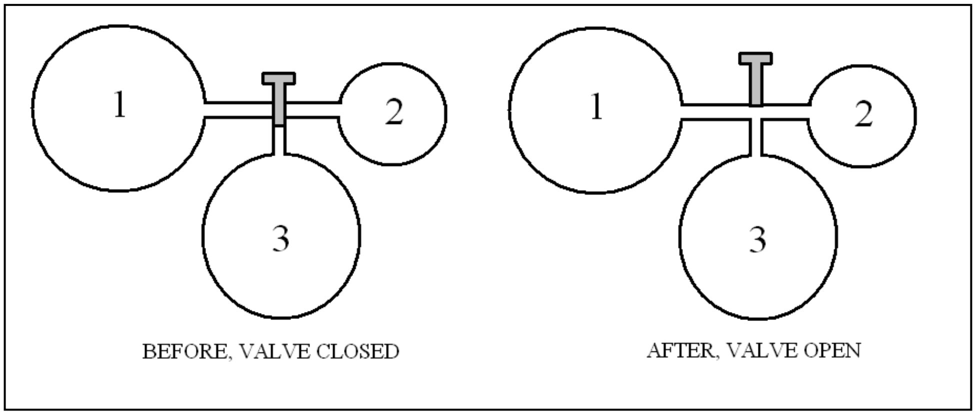
Now, let's add the number of moles together to get a total number of moles so that we can determine the MOLE FRACTION and determine the partial pressures of the each of these gases…

$$0.8924\ mol\ N_2\ +\ 0.3378\ mol\ Rn\ =\ 1.2302\ moles\ of\ gas$$

$$P_{N_2}\ =\ \left(\frac{0.8924\ mol}{1.2302\ mol}\right)\ 2580\ torr\ = 1872\ torr$$

$$P_{Rn}\ =\ \left(\frac{0.3378\ mol}{1.2302\ mol}\right)\ 2580\ torr\ = 708\ torr$$

7) Consider the flasks in the diagram to the below. In flask 1, 5.00 liters of N_2 at 720 torr. In flask 2, 1.50 liters of Ne at 1.350 atm. In flask 3, 4.00 liters of argon gas at a pressure of 433 mm Hg. What is the final partial pressure of each gas after the valve between the three flasks is opened? And then calculate the total pressure after the valve is open. (Assume the final volume is 10.50 liters)



Use the relationship $\mathbf{P_1V_1 = P_2V_2}$ *since* $\mathbf{T}$ *and* $\mathbf{n}$ *remain a constant, these are the partial pressures for each gas after the valve has been opened…*

$$N_2\ ;\ P_2 = \frac{P_1V_1}{V_2} = \frac{(720\ torr)(5.00\ L)}{10.50\ L} = 342.9\ torr$$

$$Ne\ ;\ P_2 = \frac{P_1V_1}{V_2} = \frac{(1.350\ atm)(1.50\ L)}{10.50\ L} = 0.1929\ atm$$

$$Ar\ ;\ P_2 = \frac{P_1V_1}{V_2} = \frac{(433\ mm\ Hg)(4.00\ L)}{10.50\ L} = 164.95\ mm\ Hg$$

Change all pressure units to alike units – it does not matter what you convert to…

$$P_{total} = P_{N_2} + P_{Ne} + P_{Ar}$$

$$P_{N_2} = \frac{342.9\ torr}{} \times \frac{1\ atm}{760\ torr} = 0.451\ atm$$

$$P_{Ne} = 0.1929\ atm$$

$$P_{Ar} = \frac{433\ mm\ Hg}{} \times \frac{1\ atm}{760\ mm\ Hg} = 0.217\ atm$$

$$P_{total} = 0.451\ atm + 0.1929\ atm + 0.217\ atm = 0.8609\ atm$$

8) A mixture of 25.36 grams of nitrogen dioxide gas and 76.33 grams of sulfur trioxide are placed in a 43.50 liter container at 152.0 ^{0}C. Calculate the partial pressure of each gas and the total pressure.

$$n_{NO_2} = \frac{25.36\ g\ NO_2}{} \times \frac{1\ mol\ NO_2}{46.007\ g} = 0.551\ mol\ NO_2$$

$$n_{SO_3} = \frac{76.33\ g\ SO_3}{} \times \frac{1\ mol\ SO_3}{80.06\ g} = 0.953\ mol\ SO_3$$

$$n_{NO_2} \ + \ n_{SO_3} \ = \ 0.551\ mol\ NO_2 \ + \ 0.953\ mol\ SO_3 \ = \ 1.504\ mol\ gas$$

$$P_T = \frac{nRT}{V} = \frac{(1.504\ mol)(0.0821\ atm \cdot L)(425\ K)}{(43.50\ L)(mol \cdot K)} \ = \ 1.206\ atm$$

$$P_{NO_2} \ = \ \left(\frac{0.551\ mol}{1.504\ mol}\right) \times (1.206\ atm) \ = \ 0.442\ atm$$

$$P_{SO_3} \ = \ \left(\frac{0.953\ mol}{1.504\ mol}\right) \times (1.206\ atm) \ = \ 0.764\ atm$$