CHEM 105 – Dr. Lammi Name:______________________

Quiz 5 – Take-Home – Due by start of class on Wed., Oct. 16, 2019

You <u>may</u> use your textbook and your lecture notes. You <u>may NOT</u> seek help from other people.

Useful Information: $PV = nRT$ $R = 0.08206 \frac{L \cdot atm}{mol \cdot K}$ $P_A = \chi_A P_{total}$ $\chi_A = \frac{n_A}{n_{total}}$

$\overline{E_K} = \frac{3}{2}RT$ $v_{rms} = \sqrt{\frac{3RT}{M}}$ $1\ L = 1000\ cm^3 = 0.001\ m^3$ $1\ atm = 760\ Torr = 760\ mm\ Hg$

1. Suppose that you perform a chemical reaction that produces toxic hydrogen cyanide (HCN) gas, which you collect in a sealed 1.5-L flask and allow to cool to room temperature.

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a. If the pressure of HCN in the flask is 215 Torr at 22.5 °C, how many **milligrams** of HCN does the flask contain?

$P = 215\ Torr\left(\frac{1\ atm}{760\ Torr}\right) = 0.2829\ atm$ $T = 22.5°C = 295.65\ K$

$V = 1.5\ L$

$n = \frac{PV}{RT} = \frac{(0.2829\ atm)(1.5\ L)}{(0.08206 \frac{L \cdot atm}{mol \cdot K})(295.65\ K)} = 0.01749\ mol$

Molar mass $= 1.0079 + 12.011 + 14.0067 = 27.0256\ g/mol$

$0.01749\ mol\left(\frac{27.0256\ g}{1\ mol\ HCN}\right)\left(\frac{1000\ mg}{1\ g}\right) = \underline{4.7 \times 10^2\ mg}$

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b. Suppose that the flask breaks, releasing all of the HCN into the (enclosed) room. If the room volume is 75 m^3, **what is the new gas pressure**?

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$ $n_1 = n_2$, $T_1 = T_2$ $\rightarrow$ $P_1V_1 = P_2V_2$

$P_1 = 0.2829\ atm$

$V_1 = 1.5\ L$

$V_2 = 75\ m^3\left(\frac{1\ L}{0.001\ m^3}\right) = 7.5 \times 10^4\ L$

$P_2 = \frac{P_1V_1}{V_2} = \frac{(0.2829\ atm)(1.5\ L)}{7.5 \times 10^4\ L} = \underline{5.7 \times 10^{-6}\ atm}$

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c. Due to the risk of thyroid, blood, and respiratory effects, the National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit for HCN of 5 $\frac{mg}{m^3}$. Would your exposure exceed this limit? (Be sure to show your work.)

$\frac{473\ mg\ HCN}{75\ m^3\ room\ vol.} = 6.3\ \frac{mg}{m^3}$

<u>Yes</u>; your exposure would exceed the limit.

<u>Quiz continues on reverse side</u>

2. Suppose that you fill a tire with air to a pressure of 36.7 psi (pounds per square inch; 1 atm = 14.70 psi) when the temperature is 22.1 °C.

   a. Nitrogen (N_2), oxygen (O_2) and argon (Ar) are the most prevalent gases in air. If the mole fraction of N_2 in the mixture is 0.79, what is the **partial pressure of N_2** in the tire?

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$\chi_{N_2} = 0.79$ $\quad P_{total} = 36.7\text{ psi}$ $\quad P_{N_2} = ?$

$P_{N_2} = \chi_{N_2} P_{total}$

$P_{N_2} = (0.79)(36.7\text{ psi}) = 29\text{ psi}$ (or 2.0 atm)

   b. How do the **average kinetic energies** of the nitrogen and oxygen molecules compare? **Explain** in a few words.

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They are <u>the same</u>. $\overline{E_k}$ depends only on temp. ($\overline{E_k} = \frac{3}{2}RT$), which is the same for both gases.

   c. Which of the three gases in the mixture has particles moving at the **fastest average speed,** nitrogen, oxygen, or argon? **Explain** briefly.

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$v_{rms} = \sqrt{\dfrac{3RT}{M}}$

The gas with the smallest molar mass will have the fastest average speed, v_{rms}.

$M_{N_2} \sim 28\text{ g/mol}$

$M_{O_2} \sim 32\text{ g/mol}$

$M_{Ar} \sim 40\text{ g/mol}$

Here, <u>N_2</u> is the lightest and fastest.

(Lots of extra space here!)