AP CHEMISTRY

TOPIC 3: GASES, TEST REVIEW

Day 43:

• Boyle, Charles, and Avogadro: Gas Laws • Ideal Gas Law • Gas Stoichiometry • Gas Density	• Gas Molar Mass • Dalton's Law of Partial Pressures • Gas collection over Water • Kinetic Molecular Theory of Gases	• Effusion and Diffusion • Root mean square velocity • Real Gases (van der Waals)

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1) A compressed gas cylinder contains 45.22 liters of neon gas at a pressure of 4732.0 torr at a temperature of 36.4 ^{0}C. What is the new volume if the pressure is reduced to 3000.0 torr and at a new temperature of 13.56 ^{0}C.

Answers:

$$P_1V_1 = nRT_1$$

$$P_2V_2 = nRT_2 \qquad 36.4 + 273 = 309.4\ K, \quad 13.56 + 273 = 286.56\ K$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{(4732.0\ torr)(45.22\ L)(286.56\ K)}{(3000.0\ torr)(309.4\ K)} = 66.1\ L$$

2) A 8.00 liter sample of butane gas, C_4H_{10}, reacts with a 24.0 liter sample of oxygen gas at 40.2 ^{0}C and at a pressure of 1.460 atm. Calculate the volume of the carbon dioxide gas formed at a new temperature of 103 ^{0}C and at a pressure of 3.10 atm.

Answers: $2\ C_4H_{10} + 13\ O_2 \rightarrow 10\ H_2O + 8\ CO_2$

$$n_{C_4H_{10}} = \frac{PV}{RT} = \frac{(1.460\ atm)(mol \cdot K)(8.0\ L)}{(0.0821\ atm \cdot L)(313.2\ K)} = 0.45423\ mol\ C_4H_{10}$$

$$n_{oxygen} = \frac{PV}{RT} = \frac{(1.460\ atm)(mol \cdot K)(24.0\ L)}{(0.0821\ atm \cdot L)(313.2\ K)} = 1.3627\ mol\ O_2$$

$$\frac{1.3627\ mol\ O_2}{} \times \frac{2\ mol\ C_4H_{10}}{13\ mol\ O_2} = 0.20965\ mol\ C_4H_{10}$$; ***O_2 is the limiting reactant***

$$\frac{1.3627\ mol\ O_2}{} \times \frac{8 mol\ CO_2}{13\ mol\ O_2} = 0.8386\ mol\ CO_2$$

PV=nRT ; $V = \frac{nRT}{P}$

$$V = \frac{(0.8386\ mol)(0.0821\ atm \cdot L)(376\ K)}{(3.10\ atm)(mol \cdot K)} = 8.35\ L\ CO_2$$

3) Calculate the density of a sample of gas at STP that has a molar mass of 164.3 g mol^{-1}.

Answers:

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

$$\frac{m}{V} = \frac{PM}{RT} = \frac{(1.00\ atm)(mol \cdot K)(164.3\ g)}{(0.0821\ atm \cdot L)(273\ K)(mol)} = 7.330\ g\ L^{-1}$$

4) The density of a gas was measured at 3.33 atm and 16.45 ^{0}C and found to be 4.97 g/L. Calculate the molar mass of this gas.

Answers:

PV=nRT

$$PV = \frac{m}{M}RT \qquad \textbf{\textit{therefore,}} \qquad M = \frac{m}{V} \times \frac{RT}{P}$$

$$M = \frac{4.97\ g}{L} \times \frac{(0.0821\ atm \cdot L)(289.45\ K)}{(3.33\ atm)(mol \cdot K)} = 35.5\ g\ mol^{-1}$$

5) Hydrogen gas is produced from a chemical reaction and collected over water at 25 ^{0}C and 1.07 atm total pressure. What total volume of gas must be collected to obtain 3.80 grams of hydrogen gas? (At 25 ^{0}C the vapor pressure of water is 23.8 torr.)

Answers:

$$P_{H_2} + P_{H_2O} = 1.07\_atm = 813.2\_torr = P_{H_2} + 23.8\_torr, \quad = P_{H_2} = 789.4\_torr$$

$$n_{H_2} = \frac{3.80\ g\ H_2}{} \times \frac{1\ mol\ H_2}{2.0158\ g} = 1.8851\ mol\ H_2$$

$$V = \frac{nRT}{P} = \frac{(1.8851\ mol)(0.0821\ atm \cdot L)(298\ K)}{(1.0387\ atm)(mol \cdot K)} = 44\ L\ H_2$$

6) How many times faster would nitrogen gas, N_2, diffuse than sulfur tri-oxide gas, SO_3 ?

Answers:

$$\mathbf{N_2 = 28.014\ g\ mol^{-1}}$$
$$\mathbf{SO_3 = (32.06\ g\ mol^{-1}) + (3)(16.00\ g\ mol^{-1}) = 80.06\ g\ mol^{-1})}$$

$$\frac{rate_{N_2}}{rate_{SO_3}} = \sqrt{\frac{M_{SO_3}}{M_{N_2}}} = \sqrt{\frac{80.06\,\frac{g}{mol}}{28.014\,\frac{g}{mol}}} = 1.691$$

8) Gas "X" diffuses one-eighth as fast as gas "Z". Gas "Z" has a molecular weight = 3.00 g mol^{-1}. What is the molar mass of gas "X".

Answers:

$$\frac{rate_X}{rate_Z} = \frac{1}{8} = \sqrt{\frac{M_Z}{M_X}} = \sqrt{\frac{3.00\ g}{M_X\,(mol)}}\quad \textbf{\textit{Therefore.}}$$

$$\left(\frac{1}{8} = \sqrt{\frac{3.00\ g}{M_X\,(mol)}}\right)^2 = \frac{1}{64} = \frac{3.00\ g}{M_X\,(mol)}$$

$$M_X = \frac{(64)(3.00\ g)}{(mol)} = 192\ g\ mol^{-1}$$

9) Calculate the average kinetic energy of the molecules in a sample of radon gas at 220 K.

Answers

$$(KE)_{AVE} = \frac{3}{2}\left(\frac{8.31\ J}{mol\ K}\right)(220\ K) = 2.7\times10^3\ J\ mol^{-1}$$