Non Sibi High School

Andover's Chem 300: Accelerated/Honors Chemistry

Chapter 5, Review Quiz 1 Answers

1

A sample of F_2 gas occupies a volume of 608 mL at 33°C and 723 torr. How many milligrams of F_2 are in the sample?

$$\mathrm{n} = \frac{\mathrm{PV}}{\mathrm{RT}} = \frac{\frac{723}{760}\,\mathrm{atm} \times \frac{608}{1000}\,\mathrm{L}}{0.0821\,\frac{\mathrm{L{\cdot}atm}}{\mathrm{mol{\cdot}K}} \times (33+273)\,\mathrm{K}} = 0.02302\,\mathrm{mol}\left(\frac{38.00\,\mathrm{g}}{1\,\mathrm{mol}}\right)\left(\frac{1000\,\mathrm{mg}}{1\,\mathrm{g}}\right) = 875\,\mathrm{mg}$$

2

Given the unbalanced decomposition equation $PH_3(g) \longrightarrow P_4(g) + H_2(g)$, how many kilograms of PH_3 must decompose to produce 96 liters of hydrogen gas at 715°C and 794 mmHg?

$$4PH_3(g) \longrightarrow P_4(g) + 6H_2(g)$$

$$\frac{\frac{794}{760}\,\mathrm{atm} \times 96\,\mathrm{L}}{0.0821\,\frac{\mathrm{L{\cdot}atm}}{\mathrm{mol{\cdot}K}} \times (715+273)\,\mathrm{K}} = 1.24\,\mathrm{mol\,H_2}\left(\frac{4\,\mathrm{mol\,PH_3}}{6\,\mathrm{mol\,H_2}}\right)\left(\frac{33.99\,\mathrm{g\,PH_3}}{1\,\mathrm{mol\,PH_3}}\right)\left(\frac{1\,\mathrm{kg}}{1000\,\mathrm{g}}\right) = 0.028\,\mathrm{kg\,PH_3}$$

3

Given the unbalanced equation $NH_3(g) + O_2(g) \longrightarrow NO(g) + H_2O(g)$, if 27.5 grams of NH_3 is mixed with 57.5 grams of O_2:

a. Which is the limiting reagent and what maximum volume of NO can form at STP?

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

$$27.5\,\mathrm{g\,NH_3}\left(\frac{1\,\mathrm{mol\,NH_3}}{17.03\,\mathrm{g\,NH_3}}\right)\left(\frac{4\,\mathrm{mol\,NO}}{4\,\mathrm{mol\,NH_3}}\right) = 1.615\,\mathrm{mol\,NO}$$

$$57.5\,\mathrm{g\,O_2}\left(\frac{1\,\mathrm{mol\,O_2}}{32.00\,\mathrm{g\,O_2}}\right)\left(\frac{4\,\mathrm{mol\,NO}}{5\,\mathrm{mol\,O_2}}\right) = 1.438\,\mathrm{mol\,NO}$$

O_2 produces less NO, so O_2 is the limiting reagent.

$$\frac{1.438\,\text{mol} \times 0.0821\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 273\,\text{K}}{1.00\,\text{atm}} = 32.2\,\text{L NO can form}$$

b. What mass of the excess reagent remains when the reaction is complete?

$$1.438\,\text{mol NO}\left(\frac{4\,\text{mol NH}_3}{4\,\text{mol NO}}\right)\left(\frac{17.03\,\text{g NH}_3}{1\,\text{mol NH}_3}\right) = 24.5\,\text{g NH}_3\,\text{used up}$$

$$27.5\,\text{g} - 24.5\,\text{g} = 3.0\,\text{g NH}_3\,\text{excess}$$

4

Given the unbalanced equation $K(s) + N_2(g) \longrightarrow K_3N(s)$, if 382 mL of nitrogen gas at 27°C and 704 torr react with an excess of solid potassium and then 1.63 grams of K_3N are actually collected, what is the percent yield of the reaction?

$$6K(s) + N_2(g) \longrightarrow 2K_3N(s)$$

$$\frac{\frac{704}{760}\,\text{atm} \times \frac{382}{1000}\,\text{L}}{0.0821\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times (27+273)\,\text{K}} = 0.01437\,\text{mol N}_2\left(\frac{2\,\text{mol K}_3\text{N}}{1\,\text{mol N}_2}\right)\left(\frac{131.3\,\text{g K}_3\text{N}}{1\,\text{mol K}_3\text{N}}\right) = 3.77\,\text{g K}_3\text{N theoretical}$$

$$\frac{1.63\,\text{g}}{3.77\,\text{g}} \times 100\% = 43.2\%\,\text{yield}$$

5

a. An unknown compound was found to be 24.3% carbon and 71.7% chlorine by mass, with the remainder being hydrogen. Determine the empirical formula of the compound.

$$100\% - 24.3\%\,\text{C} - 71.7\%\,\text{Cl} = 4.0\%\,\text{H}$$

Assume one hundred grams of unknown compound:

$$24.3\,\text{g C}\left(\frac{1\,\text{mol}}{12.01\,\text{g}}\right) = 2.023\,\text{mol C}$$

$$71.7\,\text{g Cl}\left(\frac{1\,\text{mol}}{35.45\,\text{g}}\right) = 2.023\,\text{mol Cl}$$

$$4.0\,\text{g H}\left(\frac{1\,\text{mol}}{1.008\,\text{g}}\right) = 3.97\,\text{mol H}$$

$$\frac{2.023}{2.023}\,\text{mol C} : \frac{2.023}{2.023}\,\text{mol Cl} : \frac{3.97}{2.023}\,\text{mol H}$$

$$\text{empirical formula} = \mathrm{CClH_2}$$

b. In a separate experiment, 2.8 grams of the vaporized compound was found to occupy 1.1 liters at 225°C and 786 mmHg. Determine the molar mass and molecular formula of the compound.

$$\frac{\frac{786}{760}\,\mathrm{atm} \times 1.1\,\mathrm{L}}{0.0821\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}} \times (225 + 273)\,\mathrm{K}} = 0.0278\,\mathrm{mol}$$

$$M = \frac{2.8\,\mathrm{g}}{0.0278\,\mathrm{mol}} = 1.0 \times 10^2\,\mathrm{g/mol}$$

$$\frac{M}{EM} = \frac{1.0 \times 10^2}{49.48} = 2$$

$$\text{molecular formula} = \mathrm{CClH_2} \times 2 = \mathrm{C_2Cl_2H_4}$$

6

What is the density of SO_2 gas at 38°C and 713 torr?

$$\mathrm{d} = \frac{M\mathrm{P}}{\mathrm{RT}} = \frac{64.07\,\frac{\mathrm{g}}{\mathrm{mol}} \times \frac{713}{760}\,\mathrm{atm}}{0.0821\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}} \times (38 + 273)\ \mathrm{K}} = 2.35\,\mathrm{g/L}$$

7

A gas sample occupies 448 mL at 615°C. If the volume is decreased to 112 mL, what will be the new temperature of the gas in °C?

$$\frac{\mathrm{V_i}}{\mathrm{T_i}} = \frac{\mathrm{V_f}}{\mathrm{T_f}}$$

$$\mathrm{T_f} = \frac{\mathrm{V_f}}{\mathrm{V_i}} \times \mathrm{T_i} = \frac{112\,\mathrm{mL}}{448\,\mathrm{mL}} \times (615 + 273)\,\mathrm{K} = 222\,\mathrm{K} - 273 = -51°\mathrm{C}$$

8

A gaseous mixture of 0.140 mol krypton and 0.280 mol xenon has a total pressure of 777 torr. Calculate the partial pressure of each gas in mmHg.

$$\mathrm{n_{total}} = 0.140\,\mathrm{mol} + 0.280\,\mathrm{mol} = 0.420\,\mathrm{mol}$$

$$\mathrm{P_{Kr}} = \frac{0.140\,\mathrm{mol}}{0.420\,\mathrm{mol}} \times 777\,\mathrm{torr} = 259\,\mathrm{torr}$$

$$\mathrm{P_{Xe}} = \frac{0.280\,\mathrm{mol}}{0.420\,\mathrm{mol}} \times 777\,\mathrm{torr} = 518\,\mathrm{torr}$$

9

When a barometer containing liquid dichloromethane was used to measure the barometric pressure, the height in the tube was found to be 7.35 meters. Given that the density of liquid dichloromethane is 1.33 g/mL and the density of liquid mercury is 13.6 g/mL, calculate the barometric pressure in atm.

$$7.35 \times 10^3\,\text{mm dichloromethane}\left(\frac{1.33\,\text{g/mL}}{13.6\,\text{g/mL}}\right) = 719\,\text{mmHg}$$

$$\text{P}_{\text{bar}} = 719\,\text{mmHg}\left(\frac{1\,\text{atm}}{760\,\text{mmHg}}\right) = 0.946\,\text{atm}$$

10

On a day when the barometric pressure was 0.932 atm, the pressure of a gas sample was measured using an open-end manometer. If the mercury level in the arm attached to the gas was 3.3 centimeters lower than the mercury level in the arm open to the atmosphere, calculate the pressure of the gas in torr.

$$\text{P}_{\text{gas}} = \text{P}_{\text{bar}} + \text{h} = (0.932 \times 760)\,\text{mmHg} + (3.3 \times 10)\,\text{mmHg} = 741\,\text{mmHg} = 741\,\text{torr}$$

11

On a day when the barometric pressure was 754 mmHg, hydrogen gas was produced in the unbalanced reaction $CaH_2(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$. The hydrogen gas was collected over water at 28°C (water vapor pressure at 28°C = 28 mmHg). If 0.0767 grams of CaH_2 reacted, how many milliliters of hydrogen gas was collected?

$$\text{CaH}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow \text{Ca(OH)}_2(\text{aq}) + 2\text{H}_2(\text{g})$$

$$0.0767\,\text{g CaH}_2\left(\frac{1\,\text{mol CaH}_2}{42.10\,\text{g CaH}_2}\right)\left(\frac{2\,\text{mol H}_2}{1\,\text{mol CaH}_2}\right) = 0.003644\,\text{mol H}_2$$

$$\text{P}_{\text{H}_2} = \text{P}_{\text{bar}} - \text{P}_{\text{water vapor}} = 754\,\text{mmHg} - 28\,\text{mmHg} = 726\,\text{mmHg}$$

$$\frac{0.003644\,\text{mol} \times 0.0821\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times (28 + 273)\,\text{K}}{\frac{726}{760}\,\text{atm}} = 0.0943\,\text{L}\left(\frac{1000\,\text{mL}}{1\,\text{L}}\right) = 94.3\,\text{mL H}_2$$

12

A 2.61 gram sample of a solid mixture contains $NaClO_3$ as well as unreactive material. When heated, only the $NaClO_3$ in the mixture decomposes to produce 992 milliliters of O_2 gas at 225°C and 772 mmHg according to the unbalanced equation $NaClO_3(s) \longrightarrow NaCl(s) + O_2(g)$. What is the percent by mass of $NaClO_3$ in the mixture?

$$2NaClO_3(s) \longrightarrow 2NaCl(s) + 3O_2(g)$$

$$\frac{\frac{772}{760}\,\text{atm} \times \frac{992}{1000}\,\text{L}}{0.0821\,\frac{\text{L·atm}}{\text{mol·K}} \times (225+273)\,\text{K}} = 0.02463\,\text{mol}\,O_2 \left(\frac{2\,\text{mol}\,NaClO_3}{3\,\text{mol}\,O_2}\right)\left(\frac{106.4\,\text{g}\,NaClO_3}{1\,\text{mol}\,NaClO_3}\right) = 1.75\,\text{g}\,NaClO_3$$

$$\frac{1.75\,\text{g}\,NaClO_3}{2.61\,\text{g}\,\text{mixture}} \times 100\% = 67.0\%\,NaClO_3\,\text{by mass in mixture}$$

13

If 0.165 mol of C_2H_6 gas effuses from a container in a certain time period, how many moles of F_2 gas would effuse under identical conditions?

$$\frac{n_{F_2}}{n_{C_2H_6}} = \sqrt{\frac{M_{C_2H_6}}{M_{F_2}}}$$

$$n_{F_2} = n_{C_2H_6} \times \sqrt{\frac{M_{C_2H_6}}{M_{F_2}}} = 0.165\,\text{mol} \times \sqrt{\frac{30.07\,\text{g/mol}}{38.00\,\text{g/mol}}} = 0.147\,\text{mol}$$

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