

# Non Sibi High School

## Andover's Chem 550/580: Advanced Chemistry

### Chapter 5, Review Quiz 1 Answers

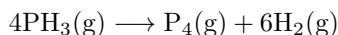
#### 1

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

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

#### 2

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

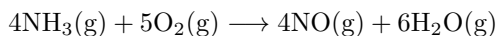


$$\frac{\frac{794}{760} \text{ atm} \times 96 \text{ L}}{0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times (715 + 273) \text{ K}} = 1.24 \text{ mol } H_2 \left( \frac{4 \text{ mol } PH_3}{6 \text{ mol } H_2} \right) \left( \frac{33.99 \text{ g } PH_3}{1 \text{ mol } PH_3} \right)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

#### 3

Given the unbalanced equation  $NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g)$ , 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?



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

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

O<sub>2</sub> produces less NO, so O<sub>2</sub> is the limiting reagent.

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

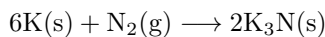
b. What mass of the excess reagent remains when the reaction is complete?

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

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

## 4

Given the unbalanced equation  $\text{K(s)} + \text{N}_2(\text{g}) \longrightarrow \text{K}_3\text{N(s)}$ , 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<sub>3</sub>N are actually collected, what is the percent yield of the reaction?



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

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

## 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:

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

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

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

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

empirical formula =  $\text{CClH}_2$

b. In a separate experiment, 2.8 grams of the vaporized compound was found to occupy 1.1 liters at  $225^\circ\text{C}$  and 786 mmHg. Determine the molar mass and molecular formula of the compound.

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

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

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

molecular formula =  $\text{CClH}_2 \times 2 = \text{C}_2\text{Cl}_2\text{H}_4$

## 6

What is the density of  $\text{SO}_2$  gas at  $38^\circ\text{C}$  and 713 torr?

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

## 7

A gas sample occupies 448 mL at  $615^\circ\text{C}$ . If the volume is decreased to 112 mL, what will be the new temperature of the gas in  $^\circ\text{C}$ ?

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

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

## 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.

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

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

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

## 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.

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

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

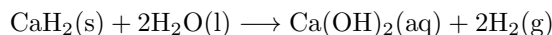
## 10

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.

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

## 11

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



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

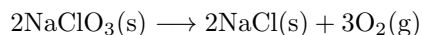
$$P_{\text{H}_2} = P_{\text{bar}} - P_{\text{water vapor}} = 754 \text{ mmHg} - 28 \text{ mmHg} = 726 \text{ mmHg}$$

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

## 12

A 2.61 gram sample of a solid mixture contains  $\text{NaClO}_3$  as well as unreactive material. When heated, only the  $\text{NaClO}_3$  in the mixture decomposes to produce 992 milliliters of  $\text{O}_2$  gas at 225°C and 772 mmHg according to the

unbalanced equation  $\text{NaClO}_3(\text{s}) \rightarrow \text{NaCl}(\text{s}) + \text{O}_2(\text{g})$ . What is the percent by mass of  $\text{NaClO}_3$  in the mixture?



$$\frac{\frac{772}{760} \text{ atm} \times \frac{992}{1000} \text{ L}}{0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times (225 + 273) \text{ K}} = 0.02463 \text{ mol O}_2 \left( \frac{2 \text{ mol NaClO}_3}{3 \text{ mol O}_2} \right) \left( \frac{106.4 \text{ g NaClO}_3}{1 \text{ mol NaClO}_3} \right) = 1.75 \text{ g NaClO}_3$$

$$\frac{1.75 \text{ g NaClO}_3}{2.61 \text{ g mixture}} \times 100\% = 67.0\% \text{ NaClO}_3 \text{ by mass in mixture}$$

### 13

If 0.165 mol of  $\text{C}_2\text{H}_6$  gas effuses from a container in a certain time period, how many moles of  $\text{F}_2$  gas would effuse under identical conditions?

$$\frac{n_{\text{F}_2}}{n_{\text{C}_2\text{H}_6}} = \sqrt{\frac{M_{\text{C}_2\text{H}_6}}{M_{\text{F}_2}}}$$

$$n_{\text{F}_2} = n_{\text{C}_2\text{H}_6} \times \sqrt{\frac{M_{\text{C}_2\text{H}_6}}{M_{\text{F}_2}}} = 0.165 \text{ mol} \times \sqrt{\frac{30.07 \text{ g/mol}}{38.00 \text{ g/mol}}} = 0.147 \text{ mol}$$

### 14

Calculate the root-mean-square speed of  $\text{O}_2$  gas at  $45^\circ\text{C}$ .

$$u_{\text{rms}} = \sqrt{\frac{3 \times 8.31 \text{ kg} \cdot \text{m}^2/\text{s}^2 \cdot \text{mol} \cdot \text{K} \times (45 + 273) \text{ K}}{\frac{32.00}{1000} \text{ kg/mol}}} = 498 \text{ m/s}$$



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 Contact: kcardozo@andover.edu