# AP CHEMISTRY

## TOPIC 3: GASES, PART B

Day 35:

- Gas Stoichiometry
- Gas Density

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1) A student adds 3.50 grams of dry ice ($CO_2$) to a empty balloon. What will be the new volume of the balloon at STP after all the dry ice sublimes?

***Answers:***

***Original Volume of balloon will be zero (no gas within the balloon when $CO_2$ was a solid )***

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

$$n = \frac{3.50\ g\ CO_2}{} \times \frac{1\ mol\ CO_2}{44.011\ g} = 0.07953\ mol\ CO_2$$

$$V = \frac{(0.07953\ mol)(0.0821\ atm \cdot L)(273\ K)}{(1\ atm)\ (mol \cdot K)} = 1.78\ L$$

2) What volume of carbon dioxide gas is generated by decomposing 325 grams of sea shells, $CaCO_3$, into calcium oxide and carbon dioxide at a temperature of 330 $^0$C and at a pressure of 1.22 atm?

***Answers:***

$$\boldsymbol{CaCO_3 \rightarrow CaO + CO_2}$$

$$n = \frac{325\ g\ CaCO_3}{} \times \frac{1\ mol\ CaCO_3}{100.091\ g} \times \frac{1\ mol\ CO_2}{1\ mol\ CaCO_3} = 3.247\ mol\ CO_2$$

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

$$V = \frac{(3.247\ mol)(0.0821\ atm \cdot L)(603\ K)}{(1.22\ atm)\ (mol \cdot K)} = 130\ L$$

3) Air bags are activated when a severe impact causes a steel ball to compress a spring and electrically ignite a detonator cap. This causes sodium azide ($NaN_3$) to decompose explosively according to the following reaction:

$$2\ NaN_{3\,(s)} \rightarrow 2\ Na_{(s)} + 3\ N_{2\,(g)}$$

What mass of $NaN_{3\,(s)}$ must be reacted to inflate an air bag to 70.0 liters at STP?

$$\boldsymbol{PV=nRT}\ ; \quad n = \frac{PV}{RT}$$

$$n = \frac{(1\ atm)\ (70.0\ L)\ (mol \cdot K)}{(0.0821\ atm \cdot L)\ (273\ K)} = 3.123\ mol\ N_2$$

$$\frac{3.123\ mol\ N_2}{} \times \frac{2\ mol\ NaN_3}{3\ mol\ N_2} = 2.082\ mol\ NaN_3$$

$$mass = \frac{2.082\ mol\ NaN_3}{} \times \frac{65.011\ g}{1\ mol\ NaN_3} = 135\ g\ NaN_3$$

4) A sample of propane gas, $C_3H_8$, having a volume of 4.88 liters at 85 $^0$C and 2.19 atm was mixed with a sample of oxygen gas with a volume of 20.2 liters at 78 $^0$C an 1.87 atm. The mixture was then ignited to form carbon dioxide and water. Calculate the volume of $CO_2$ formed at a pressure of 2.75 atm and a temperature of 230 $^0$C.

$$\boldsymbol{C_3H_8 + 5\ O_2 \rightarrow 4\ H_2O + 3\ CO_2}$$

$$n_{propane} = \frac{PV}{RT} = \frac{(2.19\ atm)\ (4.88\ L)\ (mol \cdot K)}{(0.0821\ atm \cdot L)\ (358\ K)} = 0.3636\ mol\ C_3H_8$$

$$n_{oxygen} = \frac{PV}{RT} = \frac{(1.87\ atm)\ (20.2\ L)\ (mol \cdot K)}{(0.0821\ atm \cdot L)\ (351\ K)} = 1.3108\ mol\ O_2$$

$$\frac{1.3108\ mol\ O_2}{} \times \frac{1\ mol\ C_3H_8}{5\ mol\ O_2} = 0.26216\ mol\ C_3H_8$$

***$O_2$ is the limiting reactant, All Oxygen is consumed – extra propane.***

$$\frac{1.3108\ mol\ O_2}{} \times \frac{3\ mol\ CO_2}{5\ mol\ O_2} = 0.78648\ mol\ C_3H_8$$

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

$$V = \frac{(0.78648\ mol)\ (0.0821\ atm \cdot L)\ (503\ K)}{(2.75\ atm)\ (mol \cdot K)} = 12\ L\ CO_2$$

5) The density of a gas was measured at 2.78 atm and 39.3 $^{0}$C and found to be 2.33 g/L. Calculate the molar mass of this gas.

***Answers:***

$$PV = nRT$$

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

$$M = \frac{m}{V} \times \frac{RT}{P} \quad ; \quad Density = \frac{m}{V}$$

$$M = \frac{2.33\ g}{L} \times \frac{(0.0821\ atm \cdot L)\ (312.3\ K)}{(2.78\ atm)\ (mol \cdot K)} = 21.5\ g\ mol^{-1}$$

6) Air is a mixture of about 21.0 % oxygen gas and 79.0 % nitrogen gas (we'll neglect the minor components and water vapor in this question). What is the density of air at 30.0 $^{0}$C and 1.00 atm?

***Answers:***

***Molar Mass of Air = 21% is $O_2$ and 79% is $N_2$***

$$(molar\ \ mass)_{AIR} = (0.21)(32.0\tfrac{g}{mol}) + (0.79)(28.014\tfrac{g}{mol}) = 28.85106\tfrac{g}{mol}$$

$$PV = nRT$$

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

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

$$Density_{Air} = \frac{(1.00\ atm)\ (mol \cdot K)\ (28.85106\ g)}{(0.0821\ atm \cdot L)\ (303\ K)\ (mol)} = 1.16\ g\ L^{-1}$$