

# AP CHEMISTRY

## TOPIC 3: GASES, PART B

Day 35:

- Gas Stoichiometry
  - Gas Density
- 

- 1) A student adds 3.50 grams of dry ice ( $\text{CO}_2$ ) to a empty balloon. What will be the new volume of the balloon at STP after all the dry ice sublimates?

*Answers:*

*Original Volume of balloon will be zero (no gas within the balloon when  $\text{CO}_2$  was a solid)*

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

$$n = \frac{3.50 \text{ g } \text{CO}_2}{44.011 \text{ g}} \times \frac{1 \text{ mol } \text{CO}_2}{1 \text{ mol } \text{CO}_2} = 0.07953 \text{ mol } \text{CO}_2$$

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

- 2) What volume of carbon dioxide gas is generated by decomposing 325 grams of sea shells,  $\text{CaCO}_3$ , into calcium oxide and carbon dioxide at a temperature of  $330^\circ\text{C}$  and at a pressure of 1.22 atm?

*Answers:*

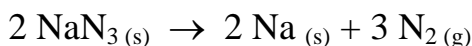


$$n = \frac{325 \text{ g } \text{CaCO}_3}{100.091 \text{ g}} \times \frac{1 \text{ mol } \text{CaCO}_3}{1 \text{ mol } \text{CaCO}_3} \times \frac{1 \text{ mol } \text{CO}_2}{1 \text{ mol } \text{CaCO}_3} = 3.247 \text{ mol } \text{CO}_2$$

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

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

- 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 ( $\text{NaN}_3$ ) to decompose explosively according to the following reaction:



What mass of  $\text{NaN}_3(\text{s})$  must be reacted to inflate an air bag to 70.0 liters at STP?

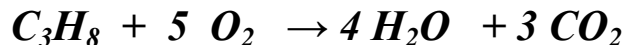
$$PV=nRT ; n = \frac{PV}{RT}$$

$$n = \frac{(1 \text{ atm}) (70.0 \text{ L}) (\text{mol} \cdot \text{K})}{(0.0821 \text{ atm} \cdot \text{L}) (273 \text{ K})} = 3.123 \text{ mol N}_2$$

$$\frac{3.123 \text{ mol N}_2}{1} \times \frac{2 \text{ mol NaN}_3}{3 \text{ mol N}_2} = 2.082 \text{ mol NaN}_3$$

$$\text{mass} = \frac{2.082 \text{ mol NaN}_3}{1} \times \frac{65.011 \text{ g}}{1 \text{ mol NaN}_3} = 135 \text{ g NaN}_3$$

- 4) A sample of propane gas,  $\text{C}_3\text{H}_8$ , having a volume of 4.88 liters at  $85^\circ\text{C}$  and 2.19 atm was mixed with a sample of oxygen gas with a volume of 20.2 liters at  $78^\circ\text{C}$  at 1.87 atm. The mixture was then ignited to form carbon dioxide and water. Calculate the volume of  $\text{CO}_2$  formed at a pressure of 2.75 atm and a temperature of  $230^\circ\text{C}$ .



$$n_{\text{propane}} = \frac{PV}{RT} = \frac{(2.19 \text{ atm}) (4.88 \text{ L}) (\text{mol} \cdot \text{K})}{(0.0821 \text{ atm} \cdot \text{L}) (358 \text{ K})} = 0.3636 \text{ mol C}_3\text{H}_8$$

$$n_{\text{oxygen}} = \frac{PV}{RT} = \frac{(1.87 \text{ atm}) (20.2 \text{ L}) (\text{mol} \cdot \text{K})}{(0.0821 \text{ atm} \cdot \text{L}) (351 \text{ K})} = 1.3108 \text{ mol O}_2$$

$$\frac{1.3108 \text{ mol O}_2}{1} \times \frac{1 \text{ mol C}_3\text{H}_8}{5 \text{ mol O}_2} = 0.26216 \text{ mol C}_3\text{H}_8$$

**$\text{O}_2$  is the limiting reactant, All Oxygen is consumed – extra propane.**

$$\frac{1.3108 \text{ mol O}_2}{1} \times \frac{3 \text{ mol CO}_2}{5 \text{ mol O}_2} = 0.78648 \text{ mol C}_3\text{H}_8$$

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

$$V = \frac{(0.78648 \text{ mol}) (0.0821 \text{ atm} \cdot \text{L}) (503 \text{ K})}{(2.75 \text{ atm}) (\text{mol} \cdot \text{K})} = 12 \text{ L CO}_2$$

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

*Answers:*

$$PV = nRT$$

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

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

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

- 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 °C and 1.00 atm?

*Answers:*

***Molar Mass of Air = 21% is O<sub>2</sub> and 79% is N<sub>2</sub>***

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

$$PV = nRT$$

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

$$\text{Density}_{\text{Air}} = \frac{m}{V} = \frac{PM}{RT}$$

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