Gas Laws

$PV = nRT$ | $R = 0.082058 \frac{L\,atm}{mol\,K}$

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

$$P_T = P_1 + P_2 + P_3 + \ldots$$

$$P_T = \frac{(n_1 + n_2 + n_3 + \ldots)RT}{V}$$

STP Standard Temp & Pressure

0°C & 1.00 atm

22.4 L = 1 mole gas @ STP

Gas Laws w/ molar mass

$$\text{Molar Mass} = \frac{\text{grams}}{\text{mole}} = \frac{\text{grams}}{n}$$

$$PV = nRT$$

Gas Laws w/ Density

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{mass}}{V}$$

$$PV = nRT$$

Mole fraction of a gas

$$\% n_A = \frac{n_A}{n_A + n_B + n_C} \times 100$$

$$\% n_A = \frac{P_A \text{ in atm or torr}}{P_A + P_B + P_C} \times 100$$

Balancing Chemical Equations

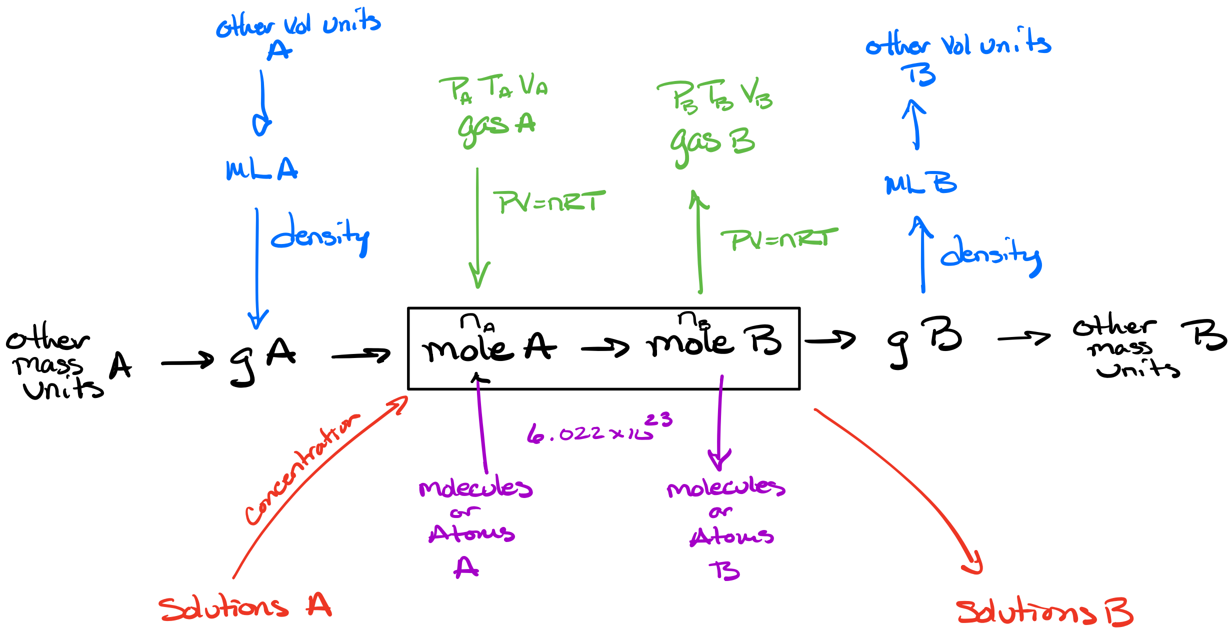
$$2\left[C_3H_6O_2 + \tfrac{7}{2} O_2 \rightarrow 3\,CO_2 + 3\,H_2O\right]$$

$9 - 2 = 7$

C	3		C	$\cancel{1}$ 3
H	6		H	$\cancel{2}$ 6
O	$\cancel{4}$ $2 + \frac{7}{2} \times 2 = 2 + 7 = 9$ ✓		O	$\cancel{3}$ $\cancel{7}$ 9 ✓

$$\boxed{2\,C_3H_6O_2 + 7\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O}$$

Stoichiometry Type Questions



Types of questions

- Given A find C

$$\begin{array}{ccccccc} A & + & B & \longrightarrow & C & + & D \\ x\,g & & & & ?\,g & & \end{array}$$

- Limiting Reagent Problem

$$\begin{array}{ccccccc} A & + & B & \longrightarrow & C & + & D \\ x\,g & & y\,g & & ?\,g & & \end{array}$$

Smallest answer for C is correct

- Percent Yield type

$$\underset{x\,g}{A} + \underset{\text{excess}}{B} \rightarrow \underset{\substack{y\,g\ \text{Actual yield} \\ \text{Theoretical } g\,C}}{C} + D$$

$$\%\text{ yield} = \frac{\text{Actual } g}{\text{Theoretical } g} \times 100$$

Example

When 7.62 g of methyl acetate ($C_3H_6O_2$) is Combusted with excess oxygen, how many grams of water will be formed?

$$2\,C_3H_6O_2 + 7\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$$

7.62 g ... ? g

$$g\ C_3H_6O_2 \rightarrow \text{mole } C_3H_6O_2 \rightarrow \text{mole } H_2O \rightarrow g\ H_2O$$

C_3H_6O $\quad 3 \times 12.01 + 6 \times 1.008 + 16.00 = 58.078\ g/mole$ (4)

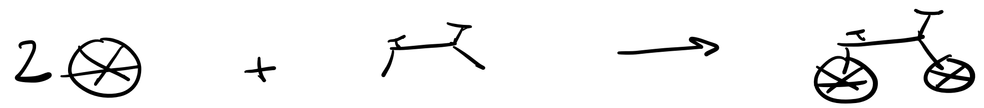
H_2O $\quad 2 \times 1.008 + 16.00 = 18.016\ g/mole$ (4)

3

$$\cancel{7.62\,g\ C_3H_6O_2} \times \frac{1\ \cancel{\text{mole } C_3H_6O_2}}{58.078\ \cancel{g\ C_3H_6O_2}} \times \frac{\overset{\text{exact}}{6}\ \cancel{\text{moles } H_2O}}{2\ \cancel{\text{mole } C_3H_6O_2}} \times \frac{18.016\ g\ H_2O}{1\ \cancel{\text{mole } H_2O}} =$$

$$7.091252\ g\ H_2O = \boxed{7.09\ g\ H_2O\ \text{Formed}}$$

Example Limiting Reagent



2 tires + frame → bike

13 tires — Limiting Reagent — Ran out before frames

9 frames

? bikes

9 Bikes

$\boxed{\text{6 Bikes}}$ + tire

Actually made

237.2 g of methyl acetate ($C_3H_6O_2$) is combusted in a chamber with 109.7 g of oxygen gas. How many grams of water can be made?

$$2\,C_3H_6O_2 + 7\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$$

237.2 g　　109.7 g　　? g

Smallest ?

A) $g\ C_3H_6O_2 \rightarrow \text{mole}\ C_3H_6O_2 \rightarrow \text{Mole}\ H_2O \rightarrow g\ H_2O$

B) $g\ O_2 \rightarrow \text{mole}\ O_2 \rightarrow \text{mole}\ H_2O \rightarrow g\ H_2O$

A) $237.2 g\ C_3H_6O_2 \times \frac{1 \text{ mole } C_3H_6O_2}{58.078 g\ C_3H_6O_2} \times \frac{6 \text{ mole } H_2O}{2 \text{ mole } C_3H_6O_2} \times \frac{18.016 g\ H_2O}{1 \text{ mole } H_2O}$

$= 220.740824 g\ H_2O$

B) $\overset{\text{Limiting}}{\overset{4}{109.7}} \cancel{g} O_2 \times \frac{\overset{4}{1 \text{ mole } O_2}}{32.00 g\ O_2} \times \frac{\overset{\text{exact}}{6 \text{ mole } H_2O}}{7 \text{ mole } O_2} \times \frac{\overset{4}{18.016 g\ H_2O}}{1 \text{ mole } H_2O} =$

$= 52.938085 g\ H_2O$ Smallest

$\boxed{= 52.94 g\ H_2O \text{ Produced}}$

Iron is produced by heating Fe_2O_3 ore in a blast furnace with carbon to produce Iron (Fe) and carbon dioxide.
If 207.9 kg of Fe_2O_3 are heated with excess carbon and produce 62.9 kg of Fe, what is the percent yield of the reaction?

$$2 Fe_2O_{3(s)} + 3 C_{(s)} \rightarrow 4 Fe_{(s)} + 3 CO_{2(g)}\uparrow$$

Fe	~~2~~	4
O	~~3~~	6
C	~~1~~	3

Fe	~~1~~	4
O	~~2~~	6
C	~~1~~	3

$$2\,Fe_2O_3 + 3\,C \longrightarrow 4\,Fe + 3\,CO_2$$

207.9 kg excess

$$\frac{62.9\text{ kg actual yield}}{\text{Theoretical}} \times 100 = \%$$

kg Fe_2O_3 → g Fe_2O_3 → mole Fe_2O_3 → mole Fe → g Fe → kg Fe

Fe_2O_3 $2 \times 55.845 + 3 \times 16 = 159.69$ g/mole

Fe 55.845 g/mole

$$\overset{4}{207.9\text{ kg } Fe_2O_3} \times \frac{\overset{\text{exact}}{1000\text{ g } \cancel{Fe_2O_3}}}{1\text{ kg } \cancel{Fe_2O_3}} \times \frac{\overset{5}{1\text{ mole } Fe_2O_3}}{159.69\text{ g } Fe_2O_3} \times \frac{\overset{\text{exact}}{4\text{ mole Fe}}}{2\text{ mole } Fe_2O_3} \times \frac{\overset{5}{55.845\text{ g Fe}}}{1\text{ mole Fe}} \times \frac{\overset{\text{exact}}{1\text{ kg } \cancel{Fe}}}{1000\text{ g } \cancel{Fe}}$$

$$= 145.4|08923\text{ kg Fe}$$

$$\%\text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{\overset{3}{62.9\text{ } \cancel{\text{kg Fe}}}}{\underset{4}{145.408}\text{ } \cancel{\text{kg Fe}}} \times 100$$

$$= 43.2|57317\,\%$$

$$\boxed{= 43.3\%\text{ yield}}$$