Calculate the mass of 22650 L of oxygen gas at 25.0 C and 1.18 atm pressure.

$\llcorner O_2$

* Volume of a 10'x10'x8' room

$O_2 : 32.00g\, O_2 = mol\, O_2$

1 - Calculate the MOLES of oxygen gas using the ideal gas law, PV=nRT
2 - Convert moles of oxygen gas to mass using FORMULA WEIGHT.

① $PV = nRT$ $P = 1.18\,atm$ $R = 0.08206 \dfrac{L \cdot atm}{mol \cdot K}$

$n = \dfrac{PV}{RT}$ $V = 22650\,L$ $T = 25.0°C = 298.2\,K$

$$n_{O_2} = \dfrac{(1.18\,atm)(22650\,L)}{(0.08206 \frac{L \cdot atm}{mol \cdot k})(298.2\,K)} = 1092.222357\,mol\, O_2$$

② $32.00g\, O_2 = mol\, O_2$

$$1092.222357\,mol\, O_2 \times \dfrac{32.00g\, O_2}{mol\, O_2} = \boxed{35000g\, O_2} \quad \begin{matrix} 35.0\,Kg \\ \sim 77\,lb \end{matrix}$$

CHEMICAL CALCULATIONS WITH THE GAS LAWS

$$FW_{NaHCO_3} = 84.007 \, g/mol$$

$$H_2SO_4(aq) + 2NaHCO_3(s) \rightarrow 2H_2O(\ell) + 2CO_2(g) + Na_2SO_4(aq)$$
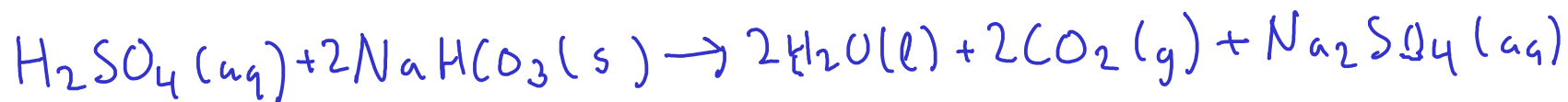
Given 25.0 g of sodium bicarbonate and sufficient sulfuric acid, what volume of carbon dioxide gas would be produced at 25.0 C and 0.950 atm pressure?

1 - Convert 25.0 grams sodium bicarbonate to moles. Use FORMULA WEIGHT.
2 - Convert moles sodium bicarbonate to moles carbon dioxide. Use CHEMICAL EQUATION.
3 - Convert moles carbon dioxide to volume. Use IDEAL GAS LAW, PV=nRT.

① $84.007 \, g \, NaHCO_3 = mol \, NaHCO_3$ ② $2 \, mol \, NaHCO_3 = 2 \, mol \, CO_2$

$$25.0 \, g \, NaHCO_3 \times \frac{mol \, NaHCO_3}{84.007 \, g \, NaHCO_3} \times \frac{2 \, mol \, CO_2}{2 \, mol \, NaHCO_3} = 0.2975942481 \, mol \, CO_2$$

③ $PV = nRT$ | $n = 0.2975942481 \, mol \, CO_2$ $T = 25.0°C = 298.2 K$

$V = \dfrac{nRT}{P}$ | $R = 0.08206 \, \dfrac{L \cdot atm}{mol \cdot K}$ $P = 0.950 \, atm$

$$V = \frac{(0.2975942481 \, mol \, CO_2)(0.08206 \frac{L \cdot atm}{mol \cdot k})(298.2 k)}{0.950 \, atm} =$$

$$= \boxed{7.67 \, L \, of \, CO_2 \, at \, 25.0°C, \, 0.950 \, atm}$$

What volume would the gas in the last example problem have at STP?

STP: "Standard Temperature and Pressure" (0 C and 1 atm)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$P_1 = 0.950 \text{ atm}$ $P_2 = 1 \text{ atm}$

$V_1 = 7.67 \text{ L}$ $V_2 = ?$

$T_1 = 298.2 \text{ K}$ $T_2 = 0^\circ C = 273.2 \text{ K}$

$$\frac{(0.950 \text{ atm})(7.67 L)}{298.2 \text{ K}} = \frac{(1 \text{ atm}) V_2}{273.2 \text{ K}}$$

$$\boxed{6.67 \text{ L at STP}} = V_2$$

REAL GASES

- The empirical gas laws (including the ideal gas equation) do not always apply.

    - The gas laws don't apply in situations where the assumptions made by kinetic theory are not valid.

        - When would it be FALSE that the space between gas molecules is much larger than the molecules themselves?
            - at high pressure, molecules would be much closer together!

        - When would it be FALSE that attractive and repulsive forces would be negligible?
            - at high pressure, attractions and repulsions should be stronger!

            - at low temperature, attractions and repulsions have a more significant affect on the paths of molecules

fast (high T)   slow (low T)
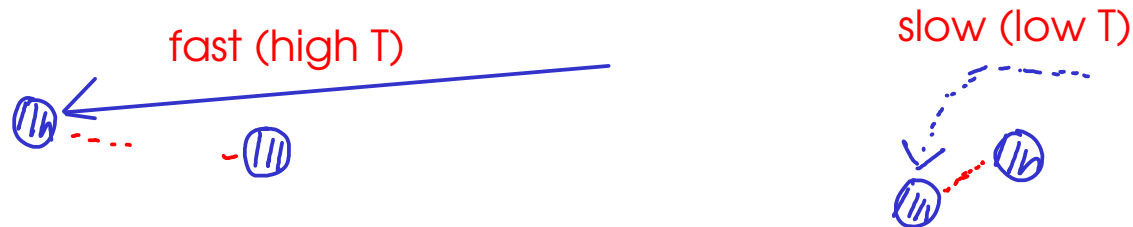
    -The gas laws are highly inaccurate near the point where a gas changes to liquid!

    - In general, the lower the pressure and the higher the temperature, the more IDEAL a gas behaves.

van der Waals equation

- an attempt to modify PV = nRT to account for several facts.

       - gas molecules actually have SIZE (they take up space)

       - attractive and repulsive forces

$$PV = nRT \qquad \text{Ideal gas equation}$$

$$\left(P + \frac{n^2 a}{V^2}\right)\left(V - nb\right) = nRT \qquad \text{van der Waals equation}$$

attempts to account for molecular size

attempts to account for attractive / repulsive forces

* "a" and "b" are experimentally determined parameters
that are different for each gas.   p 208

He: $a = 0.0346$, $b = 0.0238$ tiny, no special attractive forces

H_2O: $a = 5.537$, $b = 0.03049$ small, but strong attractions between moleculres

CH_3CH_2OH: $a = 12.56$ $b = 0.08710$ larger, and strong attractions between molecules

2500 L of chlorine gas at 25.0 C and 1.00 atm are used to make hydrochloric acid. How many grams of hydrochloric acid could be produced if all the chlorine reacts?

$$H_2 + Cl_2 \rightarrow 2\,HCl$$

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1 - Convert 2500L chlorine gas to moles. Use IDEAL GAS LAW, PV=nRT.
2 - Convert moles chlorine gas to moles HCl. Use CHEMICAL EQUATION.
3 - Convert moles HCl to mass. Use FORMULA WEIGHT.

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① $PV = nRT$ $\qquad P = 1.00\ atm \qquad R = 0.08206\ \dfrac{L\cdot atm}{mol\cdot k}$

$n = \dfrac{PV}{RT} \qquad V = 2500\,L \qquad T = 25.0^{\circ}C = 298.2\,k$

$$n_{Cl_2} = \dfrac{(1.00\ atm)(2500\,L)}{\left(0.08206\ \frac{L\cdot atm}{mol\cdot k}\right)(298.2\,k)} = 102.1646983\ mol\ Cl_2$$

② $mol\ Cl_2 = 2\,mol\ HCl$ ③ $HCl - H : 1 \times 1.008$

$\qquad\qquad\qquad\qquad\qquad\qquad Cl : 1 \times 35.45$

$\qquad\qquad\qquad\qquad\qquad\qquad \overline{36.458g}\ HCl = mol\ HCl$

$$102.1646983\ mol\ Cl_2 \times \dfrac{2\,mol\ HCl}{mol\ Cl_2} \times \dfrac{36.458\,g\,HCl}{mol\ HCl} = \boxed{7450\,g\ HCl}$$

②   ③