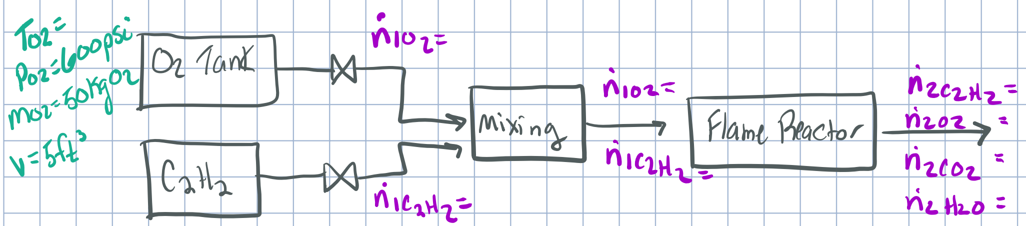
1. $\hat{V}_{ideal} >> \hat{V}_{vdW}$. If the two $\hat{V}$ are different then the gas must be violating some of the assumptions that underly the ideal gas law. Ideal gas law assumes:

1. Volume of gas >> Volume of molecule
2. No inter-molecular interactions
3. Perfectly elastic collision

It's possible that the gas is very large compared to the volume of the container making it more easily condensable. It may have attractive intermolecular interactions.

Problem 2

Combustion: $O_2 + C_2H_2 \rightarrow CO_2 + H_2O$



a) Want to know T_{O_2} tank when valve is closed.

Known: P_{O_2}, V, m_{O_2}

1. This is an incompressible fluid, so we must use EoS to relate P, V, n, R, T.
2. Need to calculate $\hat{V}$ ($\frac{L}{mol}$) to know whether $PV=nRT$ or $PV=znRT$ is valid.

O_2 is diatomic $\therefore$ $\hat{V} > 5\ \frac{L}{mol} \rightarrow$ ideal gas law

Convert $ft^3 \rightarrow L$

$$V = \frac{5ft^3}{} \left| \frac{(0.3m)^3}{(1ft)^3} \right| \frac{1000L}{m^3} = 135\ L$$

$$n = \frac{24\ kg\ O_2}{} \left| \frac{1000g\ O_2}{1kg\ O_2} \right| \frac{1\ mol\ O_2}{32.02g\ O_2} = 750\ mol\ O_2$$

$$P = \frac{600psi}{} \left| \frac{1atm}{14.7psi} \right. = 40.8atm$$

$$\hat{V}\left(\frac{L}{mol}\right) = \frac{V}{n} = \frac{135L}{750\ mol} = \underline{0.18\ \frac{L}{mol}}$$

cannot use ideal gas! $\hat{V} < 5\frac{L}{mol}$

3. Calculate V_r^{ideal}, P_r and z to use $P\hat{V} = zRT$

$$P_r = \frac{P}{P_c} = \frac{40.8\ atm}{49.8\ atm} = 0.82$$

From Table B.1

$$V_r^{ideal} = \frac{P_c\hat{V}}{RT_c} = \frac{(49.8\ atm)(0.18\ \frac{L}{mol})}{0.0821\ \frac{L\,atm}{mol\cdot K}(154.6K)} = 0.7$$

4. Use $P_r = 0.82$ and $V_r^{ideal} = 0.7$ to look up z in compressibility charts

$\underline{z = 0.60}$

5. Calculate $T_{tank} = \dfrac{P\hat{V}}{zR}$

$$T_{tank} = \frac{(40.8\,atm)(0.18\,\frac{L}{mol})}{(0.082\,L\,\frac{atm}{mol \cdot K})(0.60)}$$

$$\boxed{T_{tank} = 150K}$$

b) $P = 2\,bar$
$T = 400K$
$\dot{V} = 2\,L/min$

What is the $\dot{n}_{O_2}$?

* Assume ideal gas law (high T, low P)

$P\dot{V} = \dot{n}RT$ and $\dot{n} = \dfrac{P\dot{V}}{RT}$

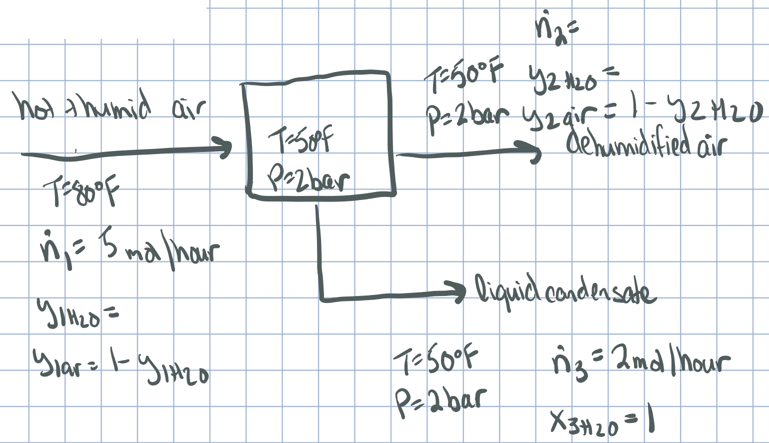
*unit conversions

$$P = \frac{2\,bar}{} \Big| \frac{0.987\,atm}{1\,bar} = 2\,atm$$

$$\dot{n} = \frac{2\,atm(2\,\frac{L}{min})}{0.082\,\frac{L\,atm}{mol\,K}(400K)}$$

$$\boxed{\dot{n} = 0.1\ mol/min}$$

Problem 3



Want to know: a) $\dot{V}_3$ b) $\dot{V}_2$ c) missing info needed for part b if $P = 200$ bar

a) $\dot{V}_3$: H_2O is an incompressible liquid. We can use the ρ and MW.

$$\frac{2\text{ mol}}{\text{hour}}\left|\frac{18.02\text{g }H_2O}{1\text{mol }H_2O}\right|\frac{1\text{kg}}{1000\text{g}}\left|\frac{1\text{L}}{1\text{kg}}\right. = \boxed{0.04 \text{ L/h}}$$

MW of H_2O, Table B.1

density of H_2O - Table B.1

b) Low P, high T. Stream 2 is a compressible fluid so we will use EOS

Convert T(°F) to K → 50°F = 283.15K
Convert 2bar to atm → 2atm

$$\hat{V} = \frac{RT}{P} = \frac{0.08206 \frac{\text{L}\cdot\text{mol}}{\text{atm}\cdot\text{K}} \cdot (283\text{K})}{2\text{atm}} = 11.6 \frac{\text{L}}{\text{mol}}$$

dehumidified air
*air is mostly diatomic
so we will use
ideal gas
$\hat{V} > 5 \frac{\text{L}}{\text{mol}}$

$$P_2\dot{V}_2 = n_2 R T_2$$

$$\dot{V}_2 = \frac{\dot{n}_2 R T_2}{P_2}$$

Need to calculate $\dot{n}_3$ from material balance

Non-reactive System in = out

$$\dot{n}_1 = \dot{n}_2 + \dot{n}_3$$

$$n_2 = 5\text{mol/h} - 2\text{mol/h} = 3\frac{\text{mol}}{\text{h}}$$

$$\dot{V}_2 = \frac{(3\ mol/h)(0.0821 \frac{L\,atm}{mol\,K})(283\,K)}{2\,atm}$$

$$\boxed{\dot{V}_2 = 35\ L/hour}$$

c) High Pressure! Probably can't use ideal gas law

$$\hat{V} = \frac{RT}{P} = \frac{0.0821 \frac{L\cdot mol}{atm\cdot K} \cdot (283\,K)}{200\,atm} = 0.11$$ ∴ Must use compressibility factor EoS

$$P_3 \dot{V}_3 = n_3 R T_3 z$$

$$\dot{V}_3 = \frac{n_3 R T_3}{P_3} z$$

To calculate z, we need the T_r and P_r.

Since this is a mixture we have to calc T'_r and P'_r using Kay's Rule.

$$T'_r = y_{2air} T_{c\,air} + y_{2H_2O} T_{c,H_2O}$$

$$P'_r = y_{2air} P_{c\,air} + y_{2H_2O} T_{c,H_2O}$$

We don't know the mole fractions of stream 2 which would be required to use any EoS other than ideal gas law.

If we look @ our DoF (without knowing Raoult's Law yet)

we don't have enough info to solve ∴

3 unknowns (y_{1H_2O} y_{2H_2O} $\dot{n}_3$)
−2 mat balances
0 add. equations

1 DoF

← Thank goodness for unit 6! That will give us extra tools for this type of problem. :)