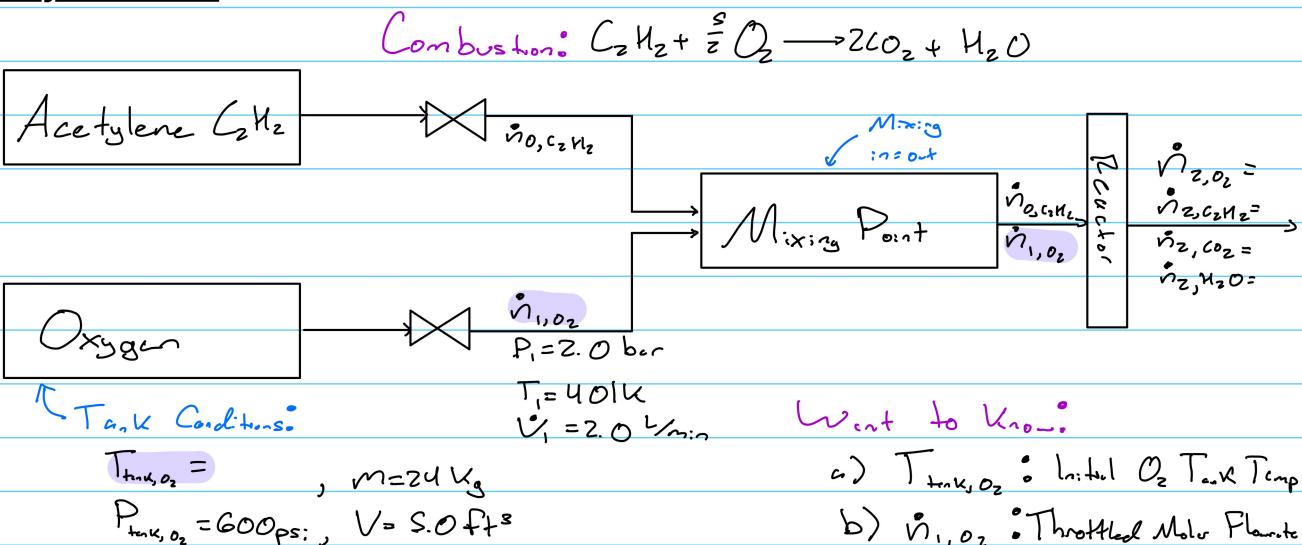


1. (5 points) You calculate the molar volume of a gas twice: (1) using the ideal gas law, you calculate \hat{V}_1 and (2) using the Warburton-Wirth equation of state for non-ideal gasses, you calculate \hat{V}_2 . You find that $\hat{V}_1 \gg \hat{V}_2$. In your own words, describe what qualities of the gas may contribute to the difference between the two molar volumes. Justify your answer and be specific.

\hat{V}_1 found with Ideal Gas Law $\left. \frac{V \in L}{\text{mol}} \right\}$ molar volume } $\hat{V}_1 \gg \hat{V}_2$
 \hat{V}_2 found from EoS for Non-Ideal Gases

The large molar volume difference suggests that the gas is not truly ideal. The ideal gas law assumes that there are a large # of molecules moving randomly, but the volume of the gas greatly exceeds volume of individual molecules, there's no intermolecular interactions, collisions are elastic, and Temperature is above $\sim 0^\circ\text{C}$ and Pressure is around 1 atm. Most likely, the gas experiences strong (or just present) intermolecular forces, the gas's particles occupy actual volume, or that the Pressure/Temperature conditions differ greatly from ideality. One or all of these factors would likely result in a large difference of molar volume. Ultimately, it can be concluded that the gas cannot be assumed to be ideal !!



a) O_2 is Diatomic, but we don't have T so we will find V_r^{ideal}

$$P = 0.0821 \frac{\text{L atm}}{\text{mol K}} \xrightarrow[\text{to atm}]{\text{Convert P}_{\text{tank}}} P_{\text{tank, } O_2} = 600 \text{ psig} \times \frac{1 \text{ atm}}{14.696 \text{ psig}} = 40.827 \text{ atm}$$

O_2 is compressible!

Convert mass to moles: $n_{\text{tank, } O_2} = 24 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } O_2}{32.00 \text{ g}} = 750 \text{ mol } O_2$

Convert Volume to L: $V_{\text{tank, } O_2} = 5.0 \text{ ft}^3 \times \frac{28.3168 \text{ L}}{1 \text{ ft}^3} = 141.584 \text{ L}$

Calculate $V := \frac{L}{\text{mol}}$: $V = \frac{141.584 \text{ L}}{750 \text{ mol}} = 0.18878 \text{ L/mol}$ \leftarrow Not ideal!

Determine T_c and P_c from Appendix B.1: For $O_{2,50}$

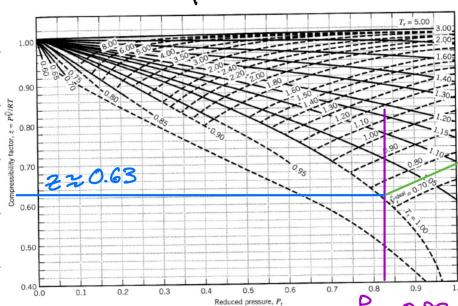
$$\begin{cases} T_c = 154.4 \text{ K} \\ P_c = 49.7 \text{ atm} \end{cases}$$

Calculate V_r^{ideal} and P_r : $V_r^{ideal} = \frac{V}{RT_c} = \frac{0.18878 \text{ L}}{(0.0821 \frac{\text{L atm}}{\text{mol K}})(154.4 \text{ K})} = 0.74$

$$P_r = \frac{P}{P_c} = \frac{40.827 \text{ atm}}{49.7 \text{ atm}} = 0.82$$

Variables
All for the
Ozone

Use V_r^{ideal} & P_r to find z
on reduced pressure tables



Using compressibility factor z to find T : $T = \frac{(40.827 \text{ atm})(0.18878 \text{ L})}{0.63(0.0821 \frac{\text{L atm}}{\text{mol K}})} = 149.011 \text{ K}$

Therefore

$$T_{\text{tank, } O_2} = 149 \text{ K}$$

Acetylene Torch (Continued)

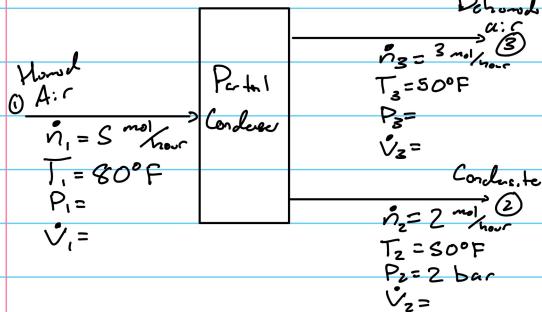
$$b) \quad 1 \text{ bar} \approx 1 \text{ atm} \Rightarrow P_1 = 2.0 \text{ atm} \quad \text{and} \quad R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

Determine \dot{V} to test ideal $\Rightarrow \dot{V} = \frac{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(40 \text{ K})}{2.0 \text{ atm}} = 16.46 \frac{\text{L}}{\text{mol}} \Rightarrow S \frac{\text{L}}{\text{mol}} \text{ Ideal!}$

$\dot{V} = 16.46 \Rightarrow S \frac{\text{L}}{\text{mol}} \Rightarrow \text{Solve for } n \text{ with Ideal Gas Law!}$

$$P_1 \dot{V}_1 = \dot{n}_{\text{O}_2} R T_1 \Rightarrow \dot{n}_{\text{O}_2} = \frac{P_1 \dot{V}_1}{R T_1} = \frac{(2.0 \text{ atm})(20 \frac{\text{L}}{\text{min}})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(40 \text{ K})} = 0.12 \text{ mol/min}$$

$$\boxed{\dot{n}_{\text{O}_2} = 0.12 \frac{\text{mol O}_2}{\text{min}}}$$

Continuous Partial Condenser

Unit Conversions! to match $R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

- Assume 1 bar $\approx 1 \text{ atm}$
- $T_1 = 80^\circ\text{F} \rightarrow T_1 = \frac{1}{1.8}(80 - 32) + 273.15 \text{ K}$

$$T_1 \approx 300 \text{ K}$$

$$T_2 = T_3 = 50^\circ\text{F} \rightarrow T = \frac{1}{1.8}(50 - 32) + 273.15 \text{ K}$$

$$T_2 = T_3 = 273.15 \text{ K} = 10^\circ\text{C}$$

a) Want to know $V_2 \in \frac{\text{L}}{\text{hour}}$

1. Liquid Water Condensate is Incompressible \rightarrow use molar volume C given conditions

$$T_2 = 10^\circ\text{C} \quad \left. \begin{array}{l} \\ \end{array} \right\} \begin{array}{l} \text{Wolfram} \\ \text{Alpha} \end{array} \quad V_2 = 18.02 \text{ cm}^3/\text{mol}$$

$$\text{Note: } \dot{V} = V \cdot \dot{n}$$

2. Determine V_2 using V_2 and \dot{n}_2

$$V_2 = 18.02 \frac{\text{cm}^3}{\text{mol}} \times 2 \frac{\text{mol}}{\text{hr}} \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.036 \frac{\text{L}}{\text{hour}}$$

$$\boxed{V_2 = 0.036 \frac{\text{L}}{\text{hr}}}$$

b) Want to know $V_3 \in \frac{\text{L}}{\text{hour}}$

Molar Balance around Condenser

$$\text{in-out+grav+cons} = \text{acc strd. strk}$$

$$\text{in} = \text{out}$$

$$\text{Total: } \dot{n}_1 = \dot{n}_2 + \dot{n}_3 \quad \left. \begin{array}{l} \\ \end{array} \right\} \dot{n}_3 = 3 \text{ mol/hour}$$

$$S = 2 + \dot{n}_3$$

1. Dehumidified Air \rightarrow T_{sat} as d.b. & r.h.

\hookrightarrow Thus: is compressible

2. Is the g.s. ideal? Let's check!

$$\sqrt[1]{3} = \frac{RT_3}{P_3} = \frac{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(273.15 \text{ K})}{P_3} \quad P?$$

Unsolvable!! We need Pressure to Proceed

c) Suppose $P_3 = 200 \text{ bar}$, now can we solve?

$$\dot{V}_3 = \frac{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(273.15 \text{ K})}{200 \text{ atm}} = 0.1162 \text{ L/mol}$$

Not ideal!

Dehumidified air is O_2/N_2 and H_2O vapor

Lets use Compress. b. b. Factor EoS, determine T_r & P_r

$$T_r' = \frac{T}{T_c'} \quad \& \quad P_r' = \frac{P}{P_c'} \quad \text{We now have } T \text{ and } P_r \text{ and can solve if we can get } T_c', P_c'$$

$$T_c' = \sum y_i T_{ci} = y_{N_2} T_{cN_2} + y_{O_2} T_{cO_2} + y_{H_2O} T_{cH_2O}$$

We can find T_{ci} & P_{ci} in Appendix B.1, but we look compositions

$$P_c' = \sum y_i P_{ci} = y_{N_2} P_{cN_2} + y_{O_2} P_{cO_2} + y_{H_2O} P_{cH_2O}$$

As it is only a partial condenser, we need species compositions to be able to solve

Reflection Question

4. (2 points) We have now concluded units 1-4 which covered unit conversions, dimensional homogeneity and the general procedure for nonreactive single- and multi-unit processes with recycle and bypass AND equations of state for ideal and non-ideal gases.

- a. Is there anything about the content that you still find confusing?
- b. What (if anything) about the class is prohibiting your learning?
- c. What (if anything) about the class is helping your learning?

A) Currently, there is not much I'm confused about in the course. I think the one thing I still need to work on is identifying when I need to use a different Extent of Reaction variable in more complex systems. Specifically when I need to differentiate between an overall extent of reaction vs. a single pass extent of reaction. I'm feeling comfortable about the rest of the content currently, and only really need to work on that and changing between the ECHE225 naming conventions and ECHE260 ones.

B) There is nothing in the class that is currently prohibiting my learning.

C) The use of example in class are extremely helpful to my learning. I also appreciated the time spent on reading the tables and making use of the actual numbers in the responses. This practice in class along with the necessary unit conversions and lessons on how to access the data really helps with the homework. Having that guided interactive learning in the classroom reinforces good habits and leads to more confidence on assignments.