

CHEM131 HOMEWORK #8 KEY

- 5-43. a. $\chi_1 = P_1/P_{\text{tot}}$; $P_{\text{CH}_4} = 0.175/(0.175 + 0.250) = 0.412$, $P_{\text{O}_2} = 0.250/(0.175 + 0.250) = 0.588$, (or more easily, $P_{\text{O}_2} = 1.000 - 0.412 = 0.588$)
- b. $n = PV/RT = (0.425 \cdot 10.5)/(0.08206 \cdot 338) = 0.161 \text{ mol}$
- c. $0.161 \cdot 0.412 \cdot 16.04 = 1.06 \text{ g CH}_4$; $0.161 \cdot 0.588 \cdot 32.00 = 3.03 \text{ g O}_2$ (fill in the units to check)
- 5-49. The molar volume of a pure gas sample $V = nRT/P$ with $n = 1$. At STP, $P = 1.0000$ and $T = 273.2$ so one mole has a volume of $0.08206 \cdot 273.2 = 22.42 \text{ L}$

The density of a pure gas is molar mass/molar volume, and for CH_4 this is $d = 16.04/22.42 = 0.7154$ and for pure He $d = 4.003/22.42 = 0.1786$

For an ideal gas mixture, $d_{\text{mix}} = f_1 d_1 + f_2 d_2$ where f_1 and f_2 are either volume fractions or mole fractions, and

$$f_1 + f_2 = 1$$

Noting that the sample specified in the problem is at STP (we could correct it if it weren't) we write

$$0.70902 = 0.7154 \cdot f_{\text{CH}_4} + 0.1786 \cdot f_{\text{He}} = 0.7154 \cdot f_{\text{CH}_4} + 0.1786 \cdot (1 - f_{\text{CH}_4}); f_{\text{CH}_4} = 98.81\%, f_{\text{He}} = 1.19\%$$

This is not an arbitrary problem, the entire world's supply of He comes from extracting small He impurities from CH_4 found in a few natural gas wells.

- 5-63. The average kinetic energy associated with the translational motion of ideal gas molecules is $3RT/2$, independent of molecule type. Note that light molecules like H_2 have much higher speeds than heavy molecules like UF_6 but the higher mass just balances the lower speed in the $(1/2)mu^2$ expression for kinetic energy.

$\text{K.E. (ave @ 273 K)} = (3/2) \cdot 0.08206 \text{ [L atm/(K mol)]} \cdot 273 \text{ K} = 33.6 \text{ L atm/mol}$; this is formally correct, but

L atm/mol is not the standard energy unit, energy should be expressed in Joules. The gas constant $R = 8.315 \text{ J/(K mol)}$ should be used. This gives $\text{K.E. (ave @ 273 K)} = 3.40 \cdot 10^3 \text{ J/mol}$. The problem asks for the average kinetic energy "of the CH_4 and N_2 molecules" and this answer is correct for one mole of molecules. If you wanted K.E. for one molecule, you would obviously divide this result by Avogadro's number to get $5.65 \cdot 10^{21} \text{ J/molecule}$. R/N is often encountered and is known as Boltzmann's constant, $k = 1.381 \cdot 10^{-23} \text{ J/K}$ (see the inside back cover of your text).

Using 546 K gives $K.E.(ave @ 546 K) = 6.81 \times 10^3 \text{ J/mol} = 1.13 \times 10^{-20} \text{ J/molecule}$.

5-71. Ideal gas diffusion is inversely proportional to the square root of the mass of the molecule and is thus inversely proportional to the square root of the molar mass: $rate1/rate2 = (mass2/mass1)^{-1/2}$. (It should be easy to remember the inverse proportionality because high speed favors high diffusion rates and high speed is associated with small mass.)

$$24.0/47.8 = (16.04/M)^{1/2}; 16.04/M = (24.0/47.8)^2 = 0.252; M = 63.6 \text{ g/mol}$$

5-129.

First calculate the mol $CO_2 = 0.8339 \text{ g } CO_2 / (44.01 \text{ g/mol}) = 0.01895 \text{ mol } CO_2$. The mol of C in the liquid is = mol $CO_2 = 0.01895 \text{ mol C}$.

Let $x = \text{mol } C_6H_{14}$ and $y = \text{mol } C_3H_8$. Then, mol C = $6x + 3y$. (6 C atoms per hexane molecule, and 3 C atoms per propane molecule)

Also, we know that we started with 0.2759 g liquid, which means $0.2759 = 86.177x + 44.096y$. (molar mass of hexane and propane is 86.177 g/mol and 44.096 g/mol, respectively.)

We have 2 equations in 2 unknowns – solve for x and y.

From the first equation we have $y = (\text{mol C} - 6x)/3$ – plug into the second equation,.

$$0.2759 = 86.177x + 44.096/3 * (\text{mol C} - 6x) \text{ – solve for x}$$

$$0.2759 - 0.27854 = 86.177x - 88.192x$$

$$2.015x = 2.64 * 10^{-3} \text{ or } x = 1.310 * 10^{-3} \text{ mol hexane} * 86.177 \text{ g hexane/mol} = 0.113 \text{ g hexane.}$$

$$y = (0.01895 - 6(1.310 * 10^{-3}))/3 = 3.697 * 10^{-3} \text{ mol propane} * 44.096 \text{ g propane/mol} = 0.1630 \text{ g propane.}$$

$$\% \text{ propane} = 0.163 / (0.163 + .113) = 59 \%, \% \text{ hexane} = 100\% - 59 \% = 41 \%$$

Next Home Work: Ch. 6: 18, 19, 21, 23