HW 13.3:

13.1C: Consider mixture of several gases of identical masses. Will all mass fractions be identical? What about mole fractions?
- Yes the mass fractions will be identical because m_i/m_{tot} & m_i's are identical.
- The mole fractions are NOT identical because each gas has a different mol #.

13.2C: The sum of the mole fractions for an ideal-gas mix. is = to 1. Is this also true for a real gas mix.

- No, we say ideal gas = 1 because we assume ideal gas behavior for the gas mixtures & each of its components. We cannot assume this when finding mole fractions for real gases.

13.3C: Claims the masses & mole fractions for a mixture, CO_2 & NO_2, are identical. Is this true?
- Yes, this is because for an ideal mixture we can say both the mass & mole fractions are identical.

13.4C: Mixture of two gases. Can the apparent molar mass of this mixture be found by taking the arithmetic average of the molar masses of individual gases? When will this case be?
- No, we can not take the arithmetic average. We can when the molar masses of the individual gases in the mixture are equal.

13.5C: What's the apparent molar mass for gas mixture? Does the mass of every molecule in mixture = the apparent molar mass?
- Apparent molar mass is the calculated average of the molar mass in the mixture.
- No, every molecule's mass doesn't = the apparent molar mass.

13.6: Use the definitions of mass & mole fractions, derive a relation between them.

Mass fraction: $m_{f_i} = \frac{m_i}{m_m}$

mole fraction: $y_i = \frac{N_i}{N_m}$

Relation: $m_{f_i} = \frac{m_i}{m_m} = \frac{N_i M_i}{N_m M_m} \Rightarrow \boxed{\frac{y_i M_i}{M_m} = m_{f_i}}$

13.7: Mixture of two gases A & B. Show the mass fractions m_{f_A} & m_{f_B} are known, mole fractions can be determined; where M_A & M_B are the molar masses of A & B:

$$y_A = \frac{M_B}{M_A\left(\frac{1}{m_{f_A}} - 1\right)} \quad \& \quad y_B = 1 - y_A$$

$N_A = \frac{m_A}{M_A}$; $N_B = \frac{m_B}{M_B}$ $\qquad m_{f_A} = \frac{m_A}{m_A + m_B}$; $m_B = (1 - m_{f_A})(m_A + m_B)$

13.8: Composition of moist air is given on molar basis of 78% of N_2, 20% of O_2, & 2% of wtr vapor. Find mass fractions of the constituents.

Molar Basis	Molar Masses (M_i)
$N_2 = 78\%$	$N_2 = 28\ kg/kmol$
$O_2 = 20\%$	$O_2 = 32\ kg/kmol$
$H_2O = 2\%$	$H_2O = 18\ kg/kmol$

$M_{mix} = (28 \times .78) + (32 \times 0.2) + (18 \times 0.0$

$M_{mix} = 28.6\ kg/kmol$

mass fraction $N_2 \Rightarrow \frac{28}{28.6} \times (.78) = \Rightarrow \boxed{m_{f_{N_2}} = .7636 \text{ or } 76.4\%}$

mass fraction $O_2 \Rightarrow \frac{32}{28.6}(.2) \Rightarrow \boxed{m_{f_{O_2}} = .2238 \text{ or } 22.4\%}$

mass fraction $H_2O \Rightarrow \frac{18}{28.6}(.02) \Rightarrow \boxed{m_{f_{H_2O}} = 0.01289 \text{ or } 1.29\%}$

13.9: Gas mixture following compression on molar basis, 60% N_2 & 40% CO_2. Find gravimetric analysis of mixture, molar mass, & gas constant.

$R_u = 8.3147 \frac{kJ}{kmol \cdot K}$

Gravimetric analysis: $N_2 = 60$ mols, $CO_2 = 40$ mols

$M_{N_2} = 28$ g/kmol

$M_{CO_2} = 44$ g/kmol

molar mass of mixture (M_m): $\left(\frac{60}{100}\right)(28 \text{ g/kmol}) + \left(\frac{40}{100}\right)(44 \text{ g/kmol}) \Rightarrow$ **34.4 g/kmol**

gas constant: $R_m = \frac{R_u}{M_m} \Rightarrow \frac{8.3147 \frac{kJ}{kmol \cdot K}}{34.4 \text{ g/kmol}} =$ **.2417 kJ/g·K**

13.10: Repeat prob. 13.9 replacing N_2 for O_2

$O_2 = 32$ g/kmol

$CO_2 = 44$ g/kmol

$R_u = 8.3147$ kJ/kmol·K

Gravimetric analysis:

$O_2 = 60$ mols

$CO_2 = 40$ mols

molar mass of mixture: $\left(\frac{60}{100}\right)(32 \text{ g/kmol}) + \left(\frac{40}{100}\right)(44 \text{ g/kmol}) =$ **36.8 g/kmol**

gas constant: $R_m = \frac{R_u}{M_m} = \frac{8.3147 \text{ kJ/kmol·K}}{36.8 \text{ g/kmol}} \Rightarrow$ **.2259 kJ/g·K**

13.11: Gas mixture of 2kg of O_2, 5kg of N_2, & 7kg of CO_2.

$M_{O_2} = 28$ kg/kmol $M_{N_2} = 28$ g/mol $CO_2 = 44$ g/kmol

a.) mass fraction of each component

$m_m = 14$ kg **$mf_{i,O_2} = .143$ $mf_{i,N_2} = .357$ $mf_{i,CO_2} = .5$**

b.) molar fraction of each component:

$Ni_{,O_2} = 32$ g/mol $Ni_{,N_2} = 28$ g/mol $Ni_{,CO_2} = 44$ g/mol

$y_i = \frac{Ni}{N_m}$ $N_m = 104$ g/mol

$y_{i,O_2} = .3076$ $y_{i,N_2} = .2692$ $y_{i,CO_2} = .4231$

c.) Avg. molar mass & gas const. of mixture:

$M_m = \sum y_i M_i =$ **37.428 g/kmol** $R_m = \frac{R_u}{M_m} =$ **.2221 kJ/kg·K**

13.12: Find mole fractions of gas mixture; 75% CH_4 & 25% CO_2 by mass. Also find gas constant of mixture.

$M_{CH_4} = 16.04$ g/mol $M_{CO_2} = 44$ g/kmol

$M_m = 44(0.75) + 16.04(.25) = \boxed{37.01 \text{ g/kmol} = M_m}$

$R_m = \frac{R_u}{M_m} = \frac{8.31447 \text{ kJ/kmol·K}}{37.01 \text{ g/mol}} = \boxed{.2247 \text{ kJ/g·K}}$

13.13: Gas mixture consists of 6 kmol of H_2 & 2 kmol of N_2. Find mass of each gas & apparent gas const. of mixture.

$6 \text{ kmol}\left(2.01 \frac{\text{kg}}{\text{kmol}}\right) = \boxed{12 \text{ kg of } H_2}$ & $2 \text{ kmol}(28.013 \text{ g/mol}) = \boxed{56 \text{ kg of } N_2}$

$R_m = \frac{8.314 \text{ kJ/kmol·K}}{8.5 \text{ kg/kmol}} = \boxed{.9782 \text{ kJ/kg·K} = R_m}$

$M_m = \frac{m_m}{N_m} = \frac{68 \text{ kg}}{8 \text{ kmol}} = 8.5 \text{ kg/kmol}$